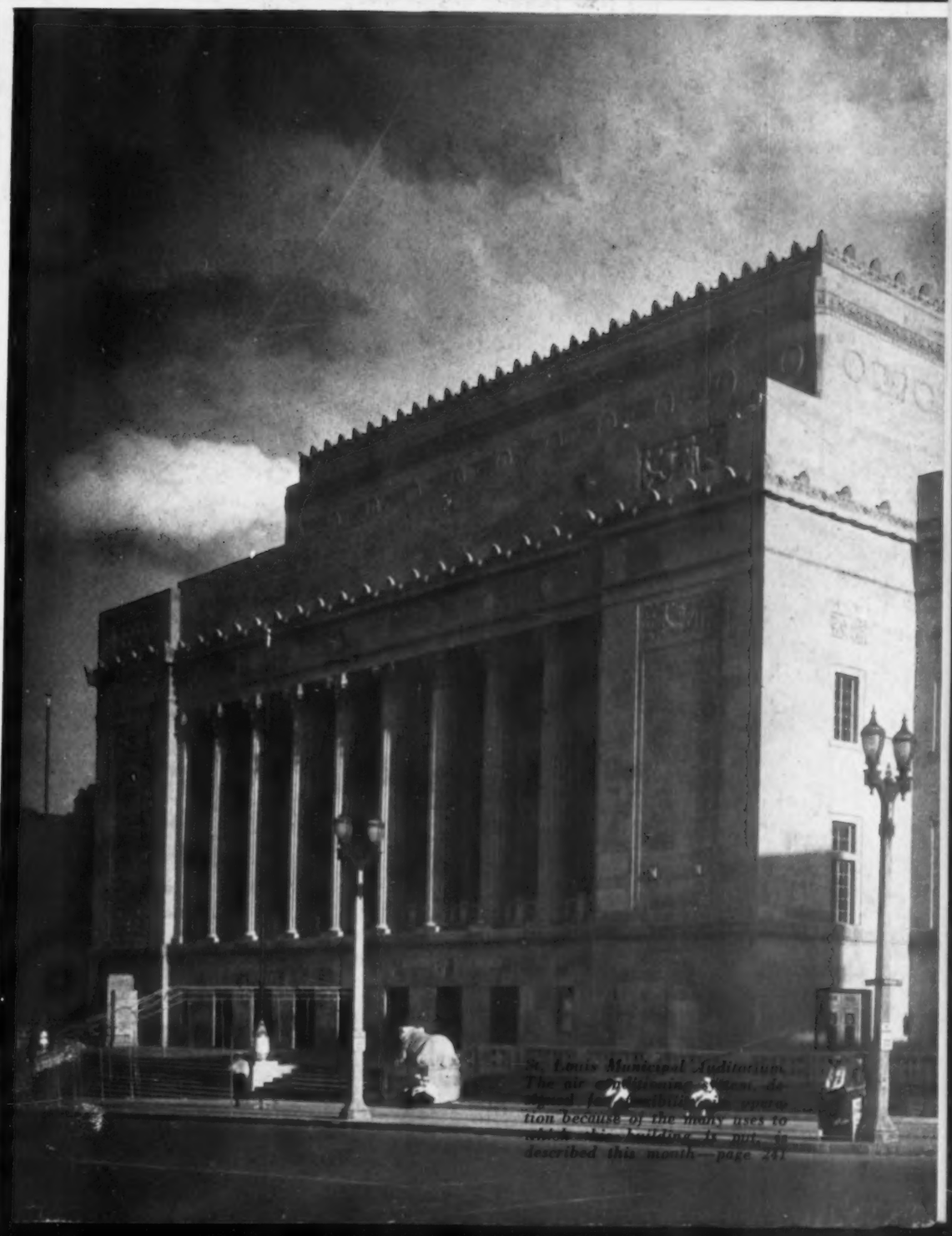
Table of Contents—Page 33

MAY 8 - 1936

Heating · Piping and Air Conditioning



St. Louis Municipal Auditorium. The air conditioning system designed for possibilities of convention because of the many uses to which the building is put, is described this month—page 241

★

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THE EDITOR'S PAGE

May, 1936

? Which of the articles published this month most interests you? On what subject would you like to see more articles? The Editors would like to know, as it will be helpful in developing material for future publication, will aid them in editing H. P. & A. C. to meet your every-day needs and interests. Your cooperation in filling in and returning the coupon will be appreciated.

The Editor,
HEATING, PIPING AND AIR CONDITIONING,
Six North Michigan Avenue,
Chicago, Illinois.

The following article in the May, 1936, H. P. & A. C. most interests me.....

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■ Five important changes in the regulations of the FHA's modernization credit plan were made necessary by the passage of the amendment extending Section 2 of Title I of the National Housing Act to April 1, 1937. Among the changes are elimination of all new construction on unimproved real property from consideration under the plan, and exclusion of loans to tenants except those who are lessees; exclusion from insurance loans or advances of credit in the amount of $2,000 or less for the purchase of and installation of equipment or machinery upon any type of improved real property, but permitting items for *additions* to real property such as heating equipment (on loans from $2,000 to $50,000 on Class A property it is not a requirement that the machinery or equipment become an addition to the property); reduction of insurance against loss to the lending agencies from 20 per cent to 10 per cent of the total amount of loans made, 20 per cent being considered a factor of safety far beyond that necessary; reduction of the liability of the Federal Housing Administrator from $200,000,000 to $100,000,000; and, fifth, placing churches in "Class A," which enables them to borrow up to $50,000 instead of $2,000 as before.

■ *Contracts for air conditioning installations in Chicago for the first quarter of 1936 were 23 per cent greater in number of jobs as compared with the first quarter of 1935, and represent an increase of 97 per cent in tonnage capacity, according to the Commonwealth Edison Co. Increase over the 1935 figure in horsepower was 79 per cent; reason the horsepower increase is lower than the capacity increase is that a 500 ton steam jet job and a 100 ton reciprocating steam engine job are included in the 1936 figures, both for department stores—the former for Carson's and the latter Mandel's.*

■ Topping last year's figures, more than 1200 have enrolled in the Massachusetts division of university extension's correspondence course on air conditioning, according to Director James A. Moyer. A varied list of trades and occupations is represented by those enrolled for the course, which is interpreted by Director Moyer to indicate that many are taking seriously the frequently expressed predictions that "air conditioning is going to be a bigger industry than automobiles." . . . Kelvinator Corp. announced last month the organization of The Temperature Research Foundation, of which Edward Heitman, Kelvinator's chief engineer, is director. Object is research and education in "temperature engineering," including air conditioning. Address of the Foundation is 80 Broadway, New York City. . . . The *Air Conditioner*, issued by the Air Conditioning Council of Kansas City, lists twenty reasons why every progressive business establishment should install air conditioning now. The reasons: It draws trade; holds and increases sales; customers spend more time shopping; increases unit sales; enhances prestige; builds good will; has advertising appeal; attracts favorable comment; discounts unfavorable location; protects merchandise from spoilage; reduces shop wear and soilage; reduces mark-downs; facilitates try-ons; increases employee efficiency; reduces labor turn-over; reduces absentees; reduces cleaning and decorating costs; reduces distractions from outside noises; increases efficiency of lighting system; enables the "boss" to be comfortable and effective at work.

■ *Which article in this month's* HEATING, PIPING AND AIR CONDITIONING *most interests you? On what subjects would you like to see more articles? The Editors would like to know, as it will be helpful in developing material for future publication, will aid them in editing H. P. & A. C. to meet your every-day needs and interests. Your cooperation in filling in and mailing the coupon on this page will be appreciated.*

■ The United States Circuit Court of Appeals has affirmed the decree of Judge Alfred Coxe of the U. S. District Court invalidating for lack of invention claims Nos. 1, 3, 13 and 14 of the Lewis re-issue patent 16,611 and claims Nos. 1, 13, 14, 17 and 20 of the Fleisher patent 1,670,656—the bypass patents. . . . Conductivity of some low temperature insulations is increased by more than 50 per cent for an increase of temperature of only 100 F, according to the annual report of Director E. R. Weidlein of Mellon Institute of Industrial research made public last month in describing the work of the Philip Carey Co. fellowship, the incumbents of which are R. H. Heilman and R. W. Ortmiller. A thorough investigation of various insulating materials in the low temperature field has been conducted because of the importance of air conditioning in plants, hotels, restaurants, theaters and residences . . . Director Weidlein also summarizes in his report the progress being made at the Institute in studies of air pollution under a fellowship the incumbent of which is H. B. Meller.

■ *A billiard parlor in El Centro, Calif., enjoyed a 50 per cent increase in patronage and $1800 worth of extra business in two months of air conditioning last sumber, according to York Ice Machinery Corp. . . . Three orders for air conditioning received by York recently totalled nearly $300,000, it is reported; they call for air conditioning the Rice building in Boston, the Davison-Paxon department store in Atlanta, and a windowless Sears, Roebuck store in Nashville, similar in construction to Sears windowless, air conditioned Chicago store.*

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CONTENTS *for* MAY, 1936

Vol. 8, No. 5 Pp. 241-302

Operating Flexibility Features Air Conditioning and Heating of New St. Louis Auditorium 241

Distillery Piping Requirements—and How They Were Met at the World's Largest Distillery, by B. C. Stewart 249

Conserves Compressed Air for Sewage Ejection by Taking Tip from Ancient Greek (Practical Piping Problems), by H. G. Schaefer 254

How to Operate Oil-Fired Heating Plants Efficiently, by Paul R. Unger and Kalman Steiner 255

Table of Properties of Pipe Aids Piping Design, by F. L. Snyder 258

New Uses for the Psychrometric Chart in Simplifying Air Conditioning Problems, by William Goodman 262

Valve Design and Construction for High Pressure Piping, by H. H. MacMillen 265

Air Conditioning Improves Quality of Honey; Apiaries Get 100% Return on Investment 268

Engineering and Equipment for Air Conditioning Charted, by H. D. Betz (back section) 102

Equipment Developments (back section) 106

Booklets, Reports and Papers (back section) 122

Correspondence—Improving Office Air Conditions (back section) 124

Conventions and Expositions (back section) 126

Book Reviews (back section) 126

Recent Trade Literature (back section) 128

Index to Advertisers (back section) 136

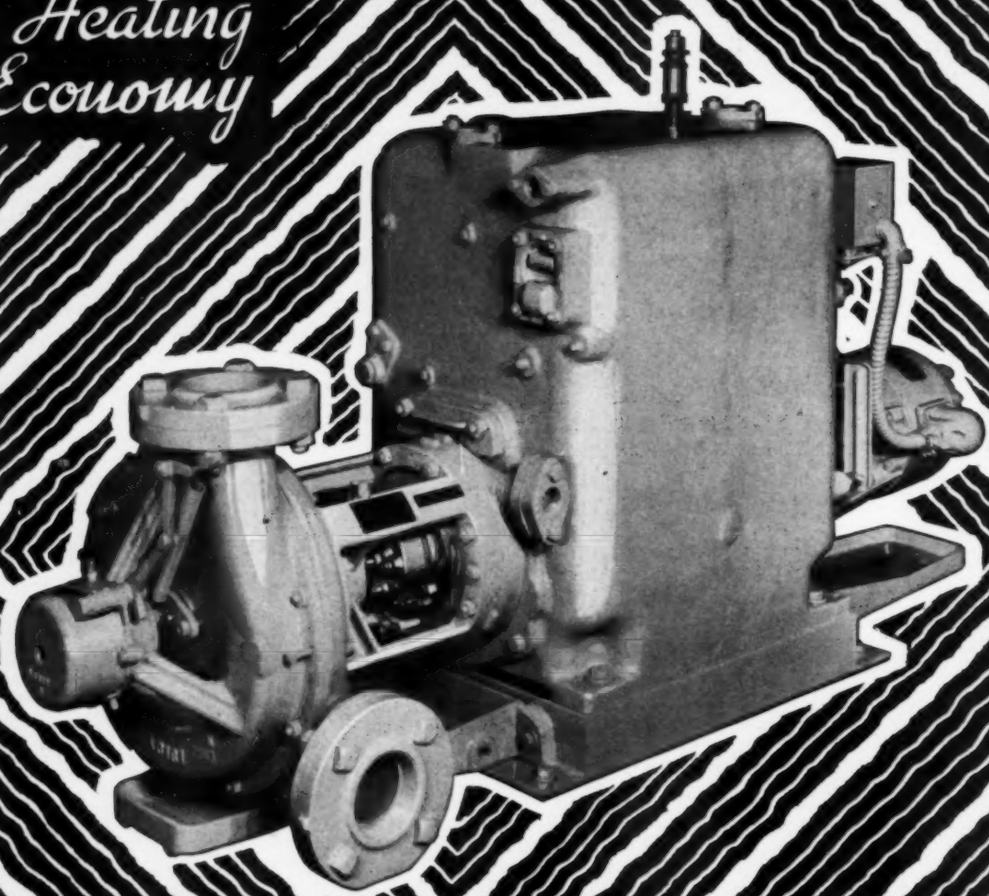
Journal Section of the American Society of Heating and Ventilating Engineers

Development of Testing Apparatus for Thermostats, by D. D. Wile 271

Study of Summer Cooling in the Research Residence Using Water from the City Water Mains, by A. P. Kratz, M. K. Fahnestock, S. Konzo and E. L. Broderick 278

Bulletin Section 289

Centralized Heating Economy



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Heating · Piping and Air Conditioning

Vol. 8, No. 5 • *May, 1936*

Operating Flexibility Features Air Conditioning and Heating of New St. Louis Auditorium

Because St. Louis' new municipal auditorium is a building of many and varied uses, it was necessary to incorporate in the design of the air conditioning and heating systems pro-

Fig. 1—The air conditioned St. Louis auditorium

visions for operating flexibility. How the job was done is described here.....Fourteen main fan room units conditioning air for a large arena, a theater, four 650 seat assembly rooms, an exhibit hall and other spaces, are supplied with chilled water from steam jet units in the machine room through an extensive piping system. Control valve equipment at each fan room permits operation of each dehumidifier independent of variations in other parts of the system

ST. LOUIS' air conditioned municipal auditorium is a building of many and varied uses; same day the photographs of the equipment were made, a symphony orchestra was rehearsing on one half of the large double stage, while on the other side of the sound-proof curtain, two hoofers were perfecting their routine for a WPA vaudeville show. Out front of the orchestra stage, workmen were taking down the prize fight ring used the night before; in the exhibit hall below, other workmen were preparing for a coming exposition and removing the cars displayed at an automobile show the preceding week. A travelogue was scheduled for the theater that evening.

Styled by Mayor Bernard F. Dickmann "the greatest civic event since the St. Louis world's fair" in 1904, the auditorium is a part of the Memorial Plaza development comprising several civic buildings. Over-all dimensions are 320 ft by 493 ft and the height is 168 ft from the street to the ridge line of the main arena.

The arena seats 12,500. The theater, or opera house, seating 3,500, is separated from the arena by a stage 145 ft long and 48 ft deep, with a proscenium serving both the opera house and arena equipped with sound-proof curtains so the stage may be used in connection with either unit; with both curtains raised, the seating capacity of both units is available at the same time. On each side of the opera house are two smaller halls to seat 650 each. The ground floor is devoted to a large exhibition space and numerous rooms of varying size for committee meetings, the press, concert rehearsals, musical library, storage rooms, dressing rooms, shops and storage.

Air Is Conditioned at 14 Fan Rooms

Air conditioning was considered essential for a building of this type in a climate such as that of St. Louis; the necessity of embodying in the design of the air conditioning and heating services the flexibility required because of the variety of uses to which the auditorium is put, the size of the job, and particularly the method of controlling the chilled water flow to each of 14 dehumid-

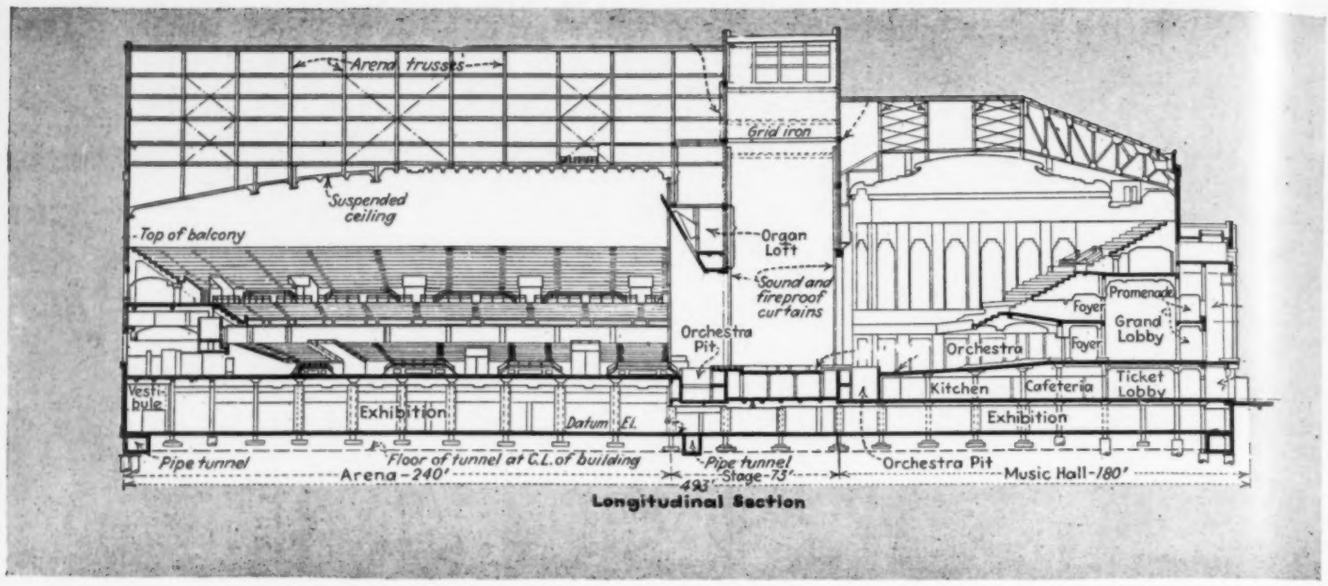


Fig. 2—Longitudinal section through building. Note tunnel for piping services to air conditioning and heating equipment

ifiers in various locations and elevations in the building make this installation of especial interest.

Briefly, the system comprises 14 fan rooms (Units Nos. 1-14), each with supply and exhaust fans, dehumidifiers, mechanical self-cleaning air filters, light weight fin type fan heating surface, centrifugal pumps, motors and accessory equipment, the washer sprays being furnished with chilled water from two 600 ton steam jet units in the basement machine room. These 14 main conditioning units handle a total of 980,000 cfm of outside air and 726,400 cfm of exhaust air, as shown in Table 1. Units 15-37 are miscellaneous exhaust fans at various locations handling 118,750 cfm of air undesirable to recirculate and driven by motors totalling 26.75 hp; there are also 32 unit ventilators handling 114,575 cfm for miscellaneous rooms to care for wall losses, 31,700 sq ft of cast iron radiation in 358 units, and 8800 sq ft of copper convector type radiation in 92 units in corridors and miscellaneous areas.

Nos. 1-4 of the 14 main units serve the exhibit space in the basement, Units 5-8 the arena, Units 9 and 10 the 3500 seat theater or music hall, Units 11 and 12 the dressing rooms, and Units 13 and 14 each serve two of the four 650 seat assembly halls.

One million, six hundred thousand pounds of copper bearing steel sheets were required for the duct work, 55,000 ft of steel pipe ranging in size from ½ to 24 in. and weighing 642,000 lb, for various piping services, and almost 82,000 ft of ¼, ⅜ and 1¼ in. O. D. copper pipe for the pneumatic system of temperature and humidity control.

Control of Chilled Water to Dehumidifiers

The scheme employed for controlling the chilled water to the dehumidifiers or air washers in each of the main fan room units permits automatic operation of each individual unit and gives the required flexibility. Chilled water is circulated to the washers from the steam jet machines in the basement through cork-covered mains in the pipe tunnel which circles the building and the risers (Fig. 3) by two 2400 gpm centrifugal pumps in the

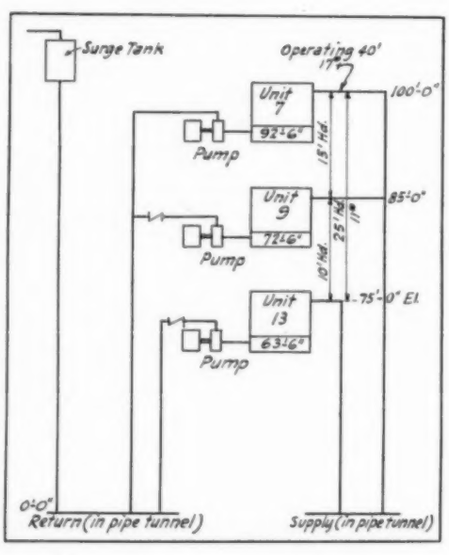


Fig. 3 (*left*)—Sketch of chilled water risers to fan room units.

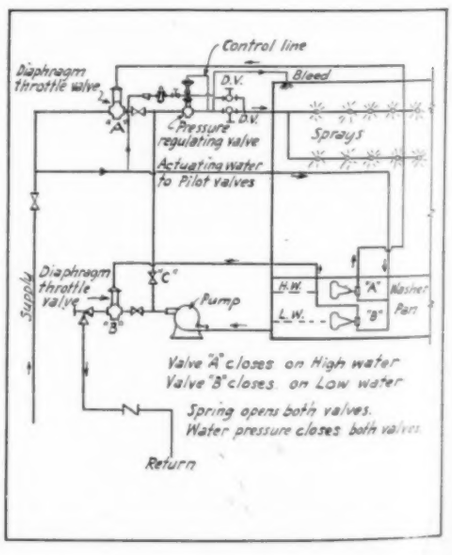


Fig. 4 (*right*) — Diagram of method of controlling chilled water to each of the fan room units and maintaining proper pressure on sprays, which permits independent operation of each unit despite variations in chilled water circulating piping

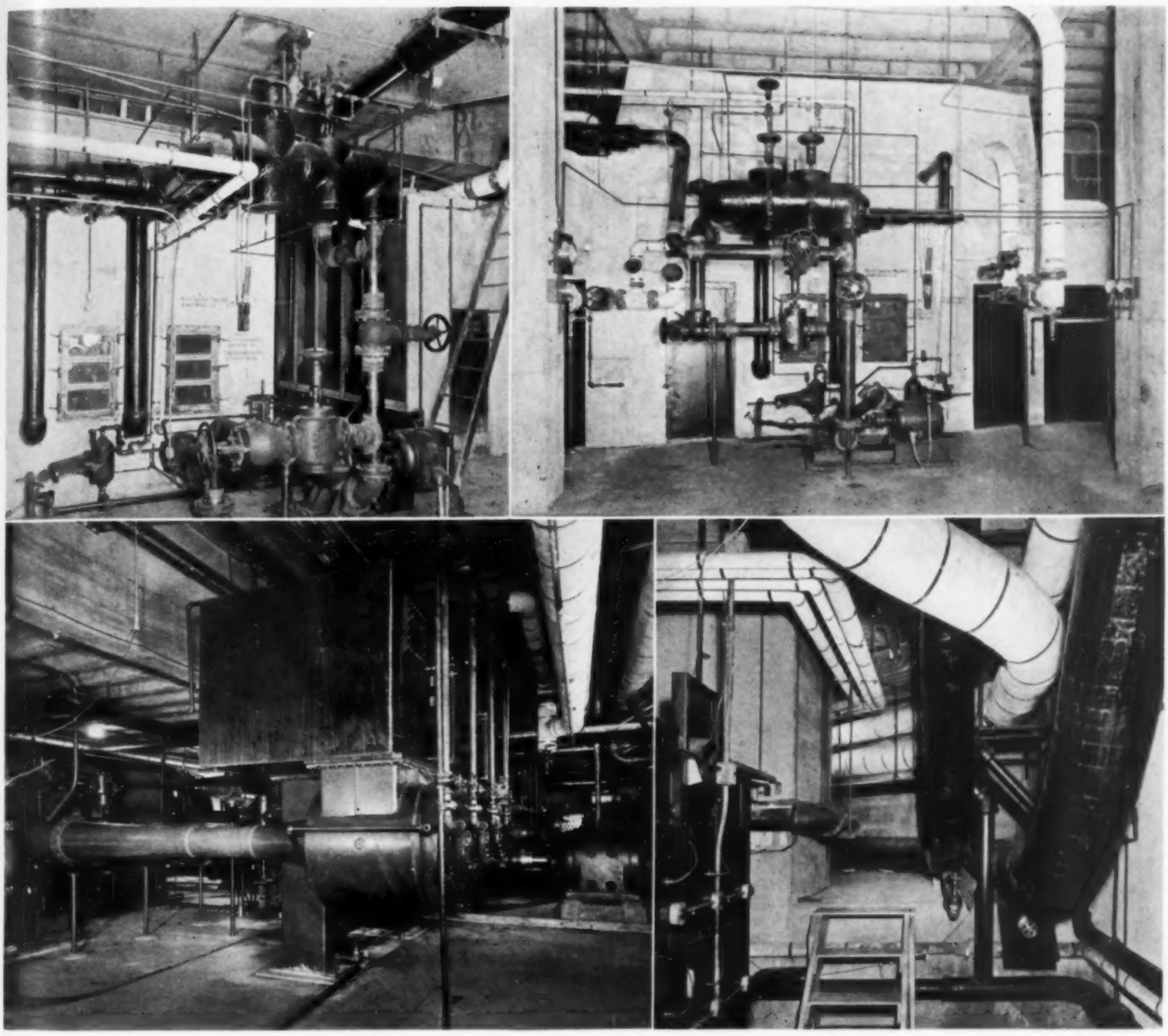


Fig. 5 (*above, left*)—Fan room No. 9, showing the dehumidifier, chilled water and steam piping, dehumidifier pump, and other equipment; Fig. 4 shows the function of these valves in controlling the chilled water. Fig. 6 (*above, right*)—Fan room No. 13, handling 50,000 cfm of fresh and 35,000 cfm exhaust air. Fig. 7 (*below, left*)—Two 600 ton steam jet units in the machine room furnish chilled water for air conditioning the auditorium. The steam supply lines to the units are seen at the top, and at the right is a 250 hp motor driving one of the two 2400 gpm chilled water circulating pumps. Fig. 8 (*below, right*)—Looking into the pipe tunnel from the machine room, showing the header supplying steam to the fan room units, the 10 in. and 5 in. heating steam mains, and the chilled water circulating piping

machine room designed to operate against a 275 ft head and each driven by a 250 hp squirrel cage motor. At each fan room, a combination of pressure regulating, diaphragm throttle valves, and liquid level controllers is installed, the object of which is to maintain a constant water pressure of approximately 20 lb per sq in. on the sprays, regardless of initial pressure variations and the number of washer units in operation at a given time, and to maintain the water level in the washer pans between predetermined high and low points to prevent, on the one hand, any danger of flooding or on the other, loss of pump suction.

Referring to Fig. 4, typical of Units 5 to 14 inclusive[1], the chilled water supply enters the fan room through a hand valve, continues through a diaphragm throttle valve, *A*, thence through the pressure regulating valve, to the washer sprays. Function of the pressure regulating valve is to maintain a constant head on the sprays. The diaphragm throttle valve functions as a safety stop valve and is actuated by a liquid level controller *A* in the washer pan; should the water approach a predetermined high level, the float mechanism in the controller rises and a pilot valve applies water to the diaphragm on the top of valve *A*, closing it to shut off the chilled water supply.

Similarly, diaphragm throttle valve *B*, in the return line, is actuated by the second liquid level controller in the washer pan, likewise marked *B*. This controller opens valve *B* on high water level in the pan (or closes with low water). Thus a constant water level is maintained in the washer pan regardless, within limitations, of variables in either chilled water supply to or return from the unit. Actuating water for the pilot valves is taken from the chilled water supply line, to assure that

[1]Units 1 to 4, installed some months before Units 5 to 14, have a slightly different method of control for the chilled water.

sufficient pressure will be available at all times.

The valves marked "D.V." on Fig. 4 are operated by thermostats in the building space served, throttling as the temperature lowers and opening as it rises.

During the tests run while the American Legion convention was in session last fall, the chilled water supply temperature was 40 F and the return temperature 49 F.

Table 1 shows the pump size for each of the fan rooms. It was found necessary to assure positive return of the water from the pans by pump rather than by depending upon gravity flow.

For winter humidification, water is recirculated through the sprays. The valves in the chilled water supply and return mains are closed and the gate valve *C* in the bypass between the dehumidifier pump discharge and the chilled water supply is opened, allowing the pump to recirculate the water through the washer. Except for winter operation, valve *C* is of course always closed.

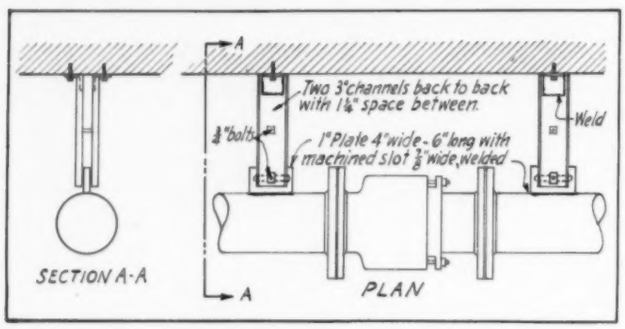


Fig. 9—Detail of pipe guide for expansion joint for steam piping in tunnel

A surge tank with overflow to the roof, indicated on Fig. 3, is installed in the chilled water return system. It is equipped with a continuous drain control to add make-up water to the system as required to compensate for losses.

Following are the instructions prepared by the contractor to assist in the proper operation of this equipment:

Before the chilled water pumps are put in service see that the following valves in each of the 14 fan rooms are tightly *closed*—

(a) Gate valve in chilled water supply main to dehumidifier.

(b) Stop valve in dehumidifier pump discharge to chilled water return main.

(c) Gate valve in bypass between dehumidifier pump discharge and chilled water supply. (This valve should always be closed except for winter operation.)

Open gate valves in supply and return risers connecting to the chilled water supply and return main located in tunnels that supply the fan rooms that are to be put into service.

After the chilled water pumps have been put into service, the following procedure should be followed—

(a) See that the following valves are *open*.

1. Valves in the branch connections supplying water to the sprays and flooding nozzles.
2. Valves in small lines supplying water to the motor pilot valves on float cages operating the diaphragm throttle valves and pilot valve operating the pressure regulating valve.

(b) After making sure that there is normal water pressure, as indicated by gauge, up to the main gate valve in chilled water supply to dehumidifier, check the operation of the diaphragm throttle valve in the supply line and in the dehumidifier pump discharge by moving gently up or down the weighted levers on their respective float cages and be sure that the small brass stem connecting the diaphragms and discs of the throttle valves has a corresponding movement sufficient to either open or close valve.

(c) Open slowly the gate valve in the chilled water supply to dehumidifier.

(d) Open valve in dehumidifier pump discharge to return main.

(e) Start dehumidifier pump.

(f) If pump has lost its prime and does not at once automatically regain it, prime same by opening valve supplying water to priming ejector and close same as soon as pump is operating properly.

(g) Watch carefully the operation of the float cages and throttle valves with respect to the water level in the dehumidifier pan. For a few moments after starting unit there will be a slight turbulence or surging of the water in the pan. This surging will rapidly decrease until the water level becomes practically normal and should be approximately 2 in. below the top of the overflow funnel.

When it is necessary to take unit out of service—

(a) First close gate valve in chilled water supply line to dehumidifier.

(b) Close valve in dehumidifier pump discharge.

(c) Close all supply valves to pilots on pressure regulating valve and on float cages.

General.—It is recommended whenever possible to close down the dehumidifier units *before* the chilled water supply pumps in machinery room are shut down.

In case the main chilled water pumps are shut down while dehumidifier units are still in operation, operator should immediately close chilled water supply valves in the following sequence —First—Units Nos. 13 and 14; Second—Units Nos. 11 and 12;

Table 1—Summary of Main Fan Room Units

Unit No.	Air Handled, Cfm		Water, Gpm			Water Pressure, Lb Sq In.	Filters, Cfm	Fan Hp		Pump Hp	Heat Surface, Sq Ft	
	Fresh	Exhaust	Flooding	Spray	Total			Fresh	Exhaust		Preheat	Temp.
1	75,000	56,500	45	745	790	24	56,500	30	15	25	4,630	2,022
2	75,000	56,500	45	745	790	24	56,500	30	15	25	4,630	2,022
3	68,000	42,000	48	666	714	24	42,000	30	10	20	3,420	1,473
4	68,000	42,000	48	666	714	24	42,000	30	10	20	3,420	1,473
5	105,000	78,800	70	1,052	1,122	26	105,000	40	20	25	5,956	2,696
6	100,000	75,000	65	1,007	1,072	26	100,000	40	20	25	5,956	2,696
7	110,000	82,500	72	1,100	1,172	26	110,000	40	20	25	5,956	2,696
8	110,000	82,500	72	1,100	1,172	26	110,000	40	20	25	5,956	2,696
9	85,000	64,000	50	840	890	24	64,000	40	20	20	4,104	2,185
10	60,000	45,000	45	585	630	24	45,000	25	12.5	15	3,420	1,473
11	13,000	16,600	15	125	140	22	13,000	7.5	5	3	696	501
12	11,000	15,000	10	106	116	22	11,000	5	3	3	696	501
13	50,000	35,000	24	501	525	24	35,000	25	10	10	2,660	1,304
14	50,000	35,000	24	501	525	24	35,000	25	10	10	2,660	1,304
Total	980,000	726,400			10,372		825,000	407.5	190.5	251	54,160	25,042

Third—Units Nos. 10 and 9; Fourth—Units 5 and 6; Fifth—Units Nos. 7 and 8; Sixth—Units Nos. 1, 2, 3 and 4.

Should the main chilled water pumps be shut down only temporarily it is advisable to check immediately the units in operation in the same sequence as given above, to make sure that the dehumidifier pumps have not lost their prime, and that the control valves are all operating properly.

Cautions.—In order to obtain sufficient water pressure to operate the diaphragm valves the supply is taken from the main chilled water supply in each fan room. This water is more or less dirty and it is imperative that the operator examine parts in pilot valves and see that all strainers are perfectly clean. This clogging of the parts is likely to occur any time, especially after a prolonged shut down of any unit.

It is necessary that the water be changed in the system before each prolonged run of the conditioning system as more or less dirt will be washed out of the air in passing through the dehumidifiers, and held in suspension by the flowing water, resulting in the clogging up of pilot valve parts and spray nozzles.

The satisfactory operation of this system will require all the attention and care that equipment of this character is entitled to. It is not fool-proof.

Steam Jet Machines and Cooling Towers

After studying the relative advantages of several methods of cooling the water circulated to each of the fan room units, steam jet refrigeration was decided upon, particularly as a municipal central steam plant in a nearby building was operated at low pressure during the summer months anyway and could supply higher pressure steam for steam jet units in the auditorium economically, as no increased attendance charge would be incurred.

Some thought was given to taking condensing water for the steam jet machines from city mains, feeding it directly back. However, this idea was given up for a number of reasons, among them being that other refrigeration plants on the same mains buy water for condensing purposes and the temperature rise of the water after passing through the auditorium's units would have been objectionable.

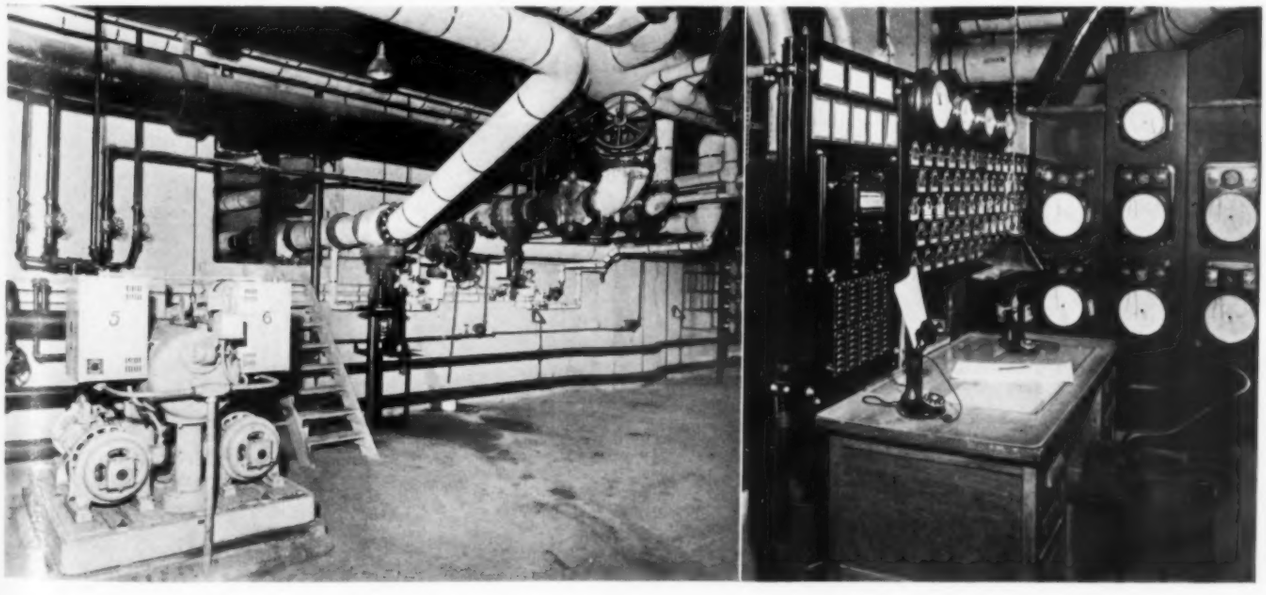
The two 600 ton steam jet refrigerating units in the machine room are shown in Fig. 7. Supplied with steam at 140 lb per sq in., each will cool 2400 gpm of water from 56 to 50 F. Each unit comprises a four jet thermal compressor, 6000 sq ft condenser using 2800 gpm of condensing water at an inlet temperature of 85 F and 105 F outlet temperature, 2400 gpm chilled water circulating pump driven by a 250 hp squirrel cage motor (one of which is seen at the extreme right of Fig. 7), 2800 gpm condenser circulating pump operating against a 125 ft head and driven by a squirrel cage motor rated at 125 hp, and a 50 gpm condensate pump operating against a 25 ft head and driven by a squirrel cage motor rated at 3 hp. It will be noted from the photograph that the steam jet machines are "upside down"; that is, with the jets below rather than above the evaporator tank. This was necessary because of limited head room, as the ceiling height of the machine room varies.

Two 2800 gpm forced draft type cooling towers designed to cool the condensing water through a range of 20 F to within 5 F of an 80 F wet bulb serve the steam jet machines. They are located accessibly over a driveway south of the building. Each tower is equipped with four 11 ft diameter propeller fans driven by 25 hp squirrel cage motors through V-belts.

The towers are made of tidewater gulf red cypress, which was specified on account of its long life. Bronze nails and galvanized bolts are used throughout. The top of each tower contains a spray eliminator to help prevent spray nuisance. Water is pumped to the top of the towers where it is discharged to an open trough distributing system, in the bottom of which are copper tubes through which the water falls to splash cups. This breaks up the water into small particles and distributes it evenly over the top of filling, consisting of a series of triangular members, and is known as the "drop-splash-film" principle.

Space is available for the installation of a third tower

Fig. 10 (*left*)—Tunnel entering the machine room, through which steam is supplied the building from a central plant across the street. To the right of the view is the pressure regulating equipment, and to the left is seen one of the three duplex vacuum pumps. At the far right is a glimpse of an instrument board. Fig. 11 (*right*)—Operating engineer's desk in the machine room



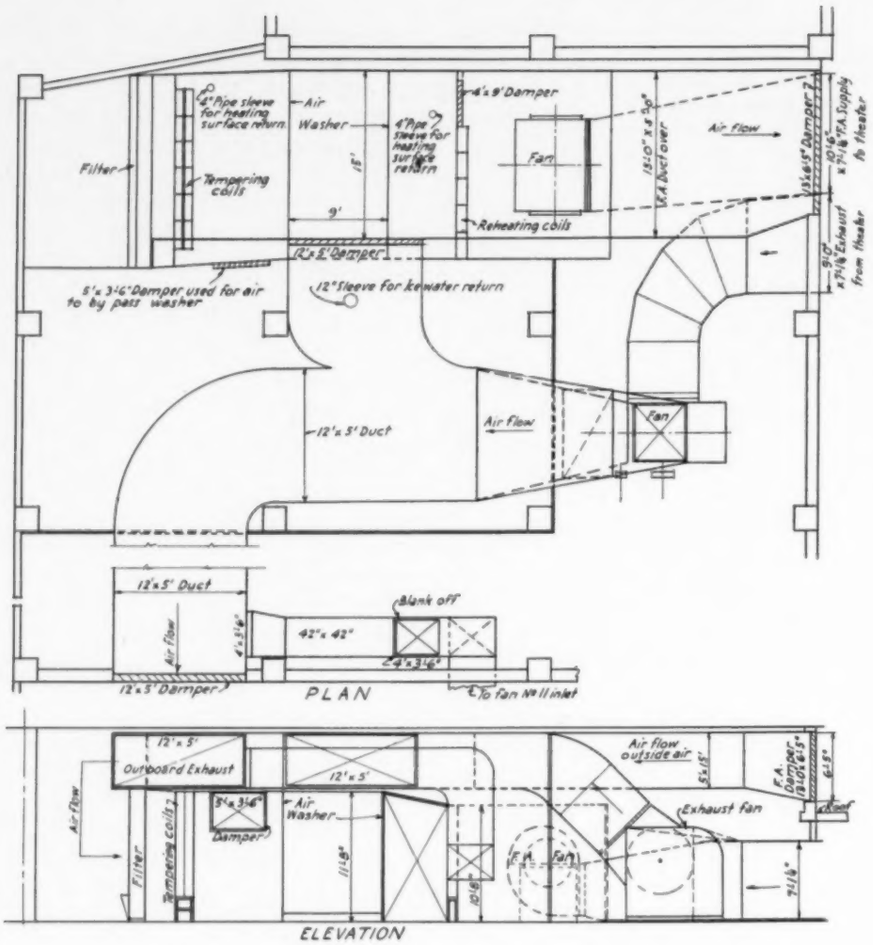


Fig. 12—Plan, above, and elevation, below, of typical fan room unit, No. 9

to serve a third steam jet unit for which space has been left in the machine room.

Piping Tunnel Circles Building

As mentioned, the water chilled by the steam jet machines is circulated to the several fan room units. To provide for piping services a piping tunnel completely circles the building, as indicated in Fig. 2 and a view of which is shown as Fig. 8 where the various lines are seen entering the tunnel from the machine room. From the mains in the tunnel, risers lead to the several fan room units for chilled water supply and return, and 5 lb steam to and condensate from the indirect heating surface. Separate mains and risers serve the direct radiation and unit ventilators with 1 lb steam, the kitchens, and the exhibit hall, which is also supplied with compressed air, water, and gas. The chilled water piping is of copper bearing steel, cork covered, and the steam piping is also copper bearing steel. Condensate return lines are wrought iron.

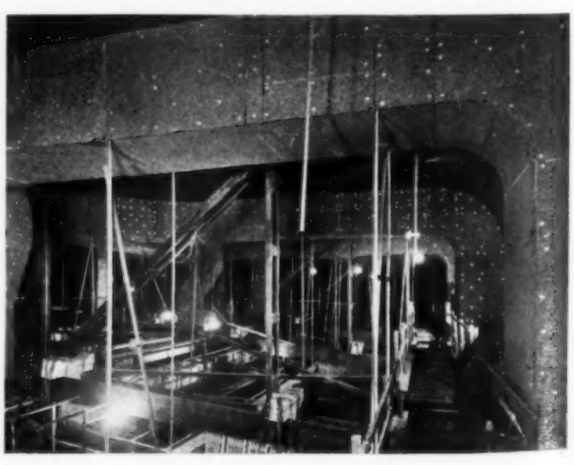
Practically all the piping was gas welded, the result being a neat appearing job as may be seen in Figs. 5 and 6. Slip expansion joints are used in the pipe tunnel; Fig. 9 shows a detail of the guides as worked out by the contractor. Two channels are bolted to the wall of the tunnel, and a plate with a machined slot was welded to the pipe, a bolt through the channels and the slot guiding the movement of the piping.

Fig. 10 shows the tunnel entering the auditorium machine room from the municipally owned steam plant in an adjacent building. Steam enters the auditorium at a pressure of approximately 160 lb and is reduced at the manifold header shown in Fig. 10 to 45 lb for kitchen, 5 lb for the fan room heating surface, and 1 lb for direct radiation.

At the left of Fig. 10, one of the three duplex vacuum pump units is shown; each of these duplex units is rated to handle the condensation from 65,000 sq ft of equivalent direct radiation, discharging 90 gpm at 40 lb per sq in. discharge head, and is driven by two 10 hp motors. Also installed in the machine room is a 260 cfm air compressor, belt driven by a 60 hp motor, supplying air at 100 lb for cleaning purposes, and two 6 sweeper stationary type vacuum cleaning units, each driven by a 15 hp motor. There are some 225 two inch vacuum cleaning heads located throughout the building.

Flow meters and temperature recorders are provided on the board seen at the right of Fig. 11 and located in the machine room, recording quantity of steam entering the auditorium, amount and temperature of condensing water to the cooling towers from each steam jet unit, quantity and temperature of water from each chilled water circulating pump, and amount of steam used by each of the refrigeration units. A board in another part of the machine room comprises indicating gauges for steam pressure in main entering building, steam pressure in main supplying indirect heating surface, north and south 10 in. heating steam mains,

Fig. 13—Above the arena, showing a part of the extensive duct system, insulated with 1 in. of corkboard. Note the direct radiation installed to care for heat loss through roof



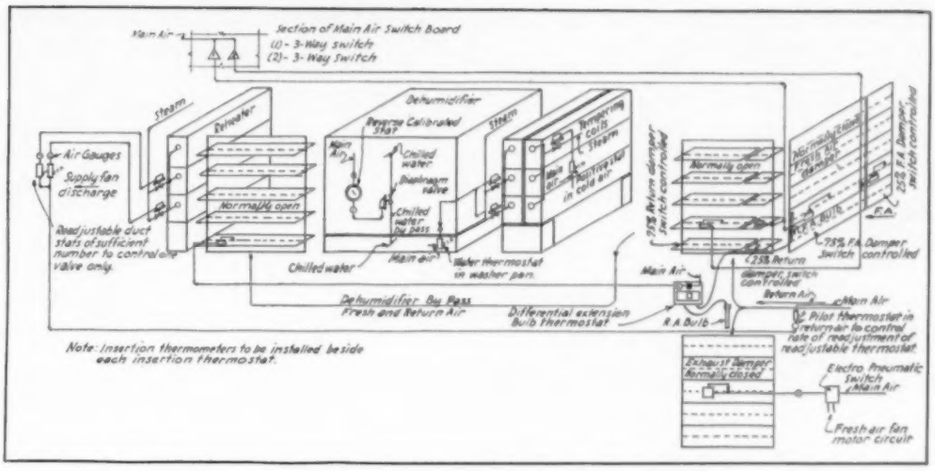


Fig. 14—Diagram showing method of pneumatic temperature and humidity control as applied to fan room unit No. 9

north and south 5 in. heating steam mains, 45 lb main supplying kitchen steam, 5 lb main supplying steam to the exhibit hall, pressure on the fire pump, compressed air pressure used for cleaning equipment, and pressure in the chilled water circulating main.

Duct Work and Air Distribution

The interesting part of the duct installation is that all of the duct work was prefabricated in the heating and air conditioning contractor's shop and erected with a minimum of labor at the building; according to the contractor "there was not a brake on the job." The drawings showed every dimension and elevations of the ducts, and a system of marking each piece was developed so that the fabricating and erecting crews knew just what each was for and where it was to go. In many cases, large ducts had to be fitted into restricted spaces and as 1,600,000 lb of copper bearing steel sheets were required for the duct systems, something of the magnitude of the undertaking and the important part played by the duct design is appreciated. Getting the equipment in place was no small job. One of the 19 ft diameter fan wheels weighs 3 tons and as it was balanced by the manufacturer could not be dis-assembled for erection. It had to be hoisted from the ground level up through a hole in the arena ceiling affording but a few inches clearance.

Fig. 12 shows a plan and elevation of Fan Unit No. 9, which is typical of the major fan units and a photograph of which appears as Fig. 5. This unit, one of two serving the 3500 seat theater, handles 85,000 cfm of fresh air and 64,000 cfm of exhaust air. The exhaust fan draws air from the conditioned space at the floor level and pulls it toward openings to the outside air or to the recirculated air intake. These openings are of such size that a maximum of 75 per cent air can be recirculated, and the proportion of recirculated air can be reduced until all outside air is used if desired. Fresh air enters the building, mixes with the recirculated air (if any is being used) and passes through the air filter and heating coils into the air washer or dehumidifier.

Fig. 13 is a photograph of the supply ducts for the arena above the suspended ceiling. The main supply runs from the fan units above the center line of the arena (toward the left of Fig. 13) and the branches may be seen leading off from this duct dropping to coves along the center and at the sides where the air is introduced. The ducts are completely insulated with 1 in. of corkboard and the dehumidifiers with 2 in. corkboard.

Air is exhausted from the arena through several hundred mushrooms beneath the balcony and main floor seats, and through large grilles at the floor level. Air distribution has been found to be thoroughly satisfactory, the mushrooms pulling the air back up under the overhang of the balcony to serve the main floor tier of seats without any dead spots. In a space of such large size, the air distribution problem is simplified because of the large volume of air circulated and the numerous return openings available.

In one part of the basement exposition hall or exhibit space, air is supplied through combination air outlets and lighting fixtures. In the balance of this area, air is supplied through openings at the top of false columns, return air being taken out at the floor level of alternate columns.

Temperature, Humidity and Motor Control

Based on the design condition of 100 F dry bulb and 80 F wet bulb outdoors, it was calculated that 2480 tons of refrigeration would be required for air conditioning the auditorium. Because of the variety of uses to which the building is put, a load factor of 50 per cent was applied, and thus 1200 tons of refrigeration capacity was installed.

Conditioned air is introduced to the building at 61 F, the relative humidity being allowed to vary within limits of 40 and 50 per cent to maintain conditions within the comfort zone. A complete system of pneumatic temperature and humidity control governs operation of the system, and incorporates a reset feature to maintain indoor conditions in a balance with outdoor dry bulb temperature. Fig. 14 is a typical diagram of the method of control as applied to Fan Unit No. 9.

To aid in operation of the system, an electrical resistance method of reading wet and dry bulb temperatures at various locations throughout the building and at the conditioning units is provided, with the indicating instruments at the engineer's desk in the machine room, Fig. 11, extreme left. In the center of Fig. 11 is the panel board for the pneumatic operation of the dampers throughout the system, each of the levers operating a damper from this point.

The motors for the heating and air conditioning equip-

ment were selected to keep the maximum electric current demand as low as possible and the advantage of every low starting load requirement was taken to this end.[2] Also, multi-speed motors were used to add flexibility to the operation and the ability of the installation to meet varying conditions and a wide season change. The fan motors for both the exhaust and supply fans are two speed, with the exception of three speed motors on the

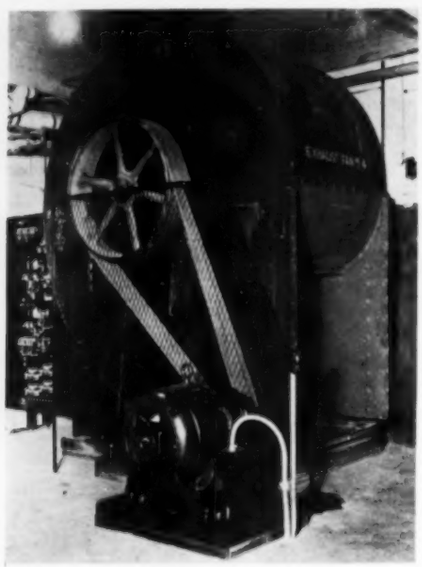


Fig. 15—Exhaust fan No. 4 for exhibit space

supply fans for the basement exposition hall for greater flexibility.

These multi-speed motors are connected through magnetic starting equipment with overload and low voltage protection, directly across the line, with compelling relays to insure starting on low speed regardless of the ultimate speed setting at the main switchboard, where speed adjustment and stopping are controlled. This again keeps the maximum demand low without interfering with flexibility of operation. Since the motors are started at the motor, manual control could have been used but not at a lower cost for the same protection. All fan and pump motors have non-fusible, inter-locking safety switches.

All multi-speed motors whose slow speed size is 7½ hp or larger are normal torque, low current motors. Therefore, current limiting starting equipment is unnecessary because the current is within the limits for full voltage across-the-line starting and the low horsepower draws relatively low current from the line.

The pump motors for the dehumidifier pumps (one in each fan room) are single speed, normal torque, low current motors. These motors drive centrifugal pumps which again make it possible to use the low current motor and lower the maximum demand load.

It would have been possible to select a slip ring type variable speed motor for driving fans instead of the multi-speed squirrel cage type. The slip ring motor, however, has a lower efficiency when operated at slow speeds than the multi-speed squirrel cage type and the control equipment is considerably more complicated. It would be possible, of course, with the slip ring motor to obtain a larger number of speeds, but since two or three speeds are all that are necessary to accomplish the desired purpose, it is apparent that the multi-speed squirrel cage type is better suited to the particular application.

The horsepower ratings of the fan motors on the lowest speeds are one-fourth of the horsepower rating at the highest speeds. For example, a fan motor rated at 40 hp at 1200 rpm is designed as a 10 hp motor for the 600 rpm speed. Magnetic starters are provided for these motors and compelling relays are installed on the starters to compel starting of the motors on low speed. In this way advantage is taken of the low horsepower rating of the low speed winding to reduce the starting current.

Incidentally, in order to insure good voltage regulation on the motor circuits in the building, without the necessity of using exceptionally large section copper wire from the main distribution point in the building to the motors, all motors 1 hp and larger are served at 440 volts, 3 phase, 60 cycles.

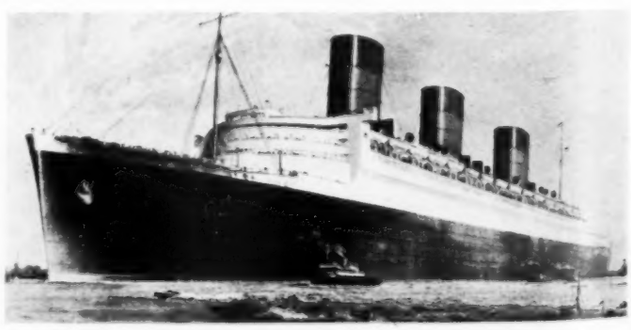
Any motor can be started or stopped from a push button station adjacent to the motor itself. In addition, any of the multi-speed motors can be changed in speed or stopped and any pump motor can be stopped from a push button control panel in the main machinery room; this panel has indicating lights to show the motors in operation. Note, however, that it is not possible to start any motor from the main machinery room. It is necessary for an operator actually to be in the fan room in order to start any fan or pump motor, which insures an opportunity of the attendant observing whether all equipment is functioning properly.

The motors operating the air filters are interlocked with the magnetic starters for the pump motors. This insures the filter motors being in operation at any time the pumps are operating.

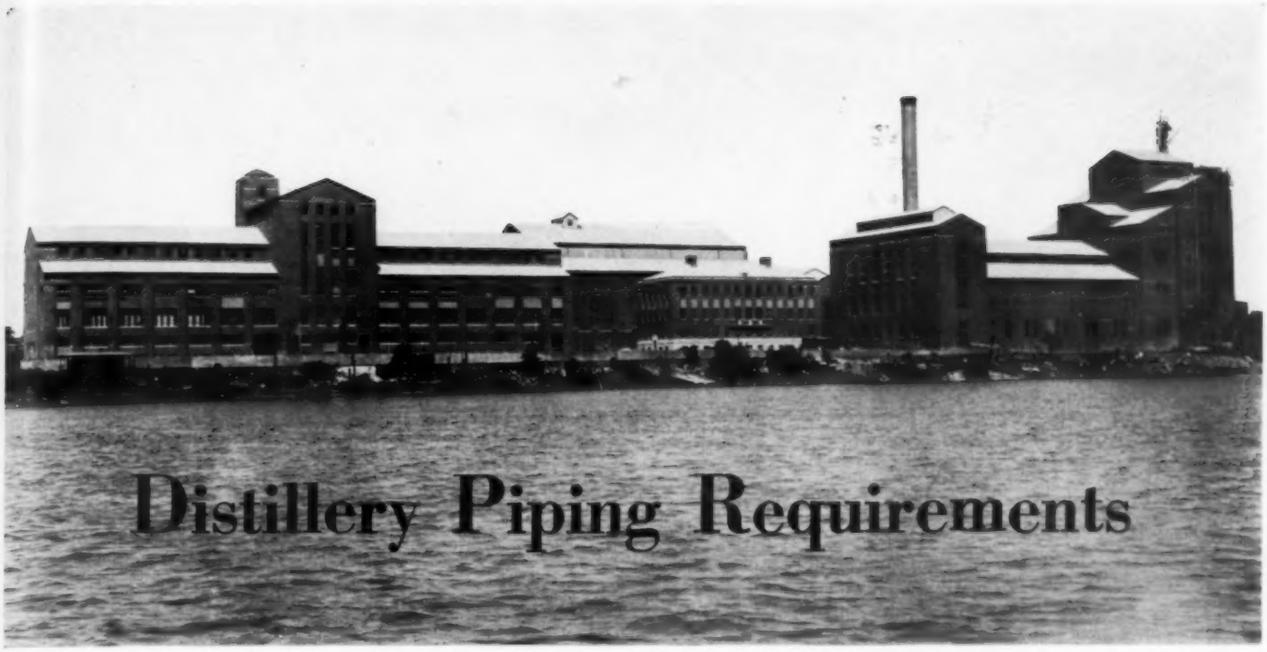
A second push button master control panel in the machine room is provided for the motors driving the cooling tower fans, chilled water pumps, and the condenser water pumps.

Architects for the auditorium were The Plaza Commission, Inc., and La Beaume & Klein, and the consulting engineer was George E. Wells, Inc. The heating and air conditioning contractors were the Midwest Piping and Supply Co. The cooperation of W. G. Hooper, R. R. Wischmeyer, and Herman Buss of the latter organization and R. M. McCracken, engineer of the building, in furnishing data and cooperating in this description is gratefully acknowledged.

[2]For further information on selection of the fan room motors, see article by Oliver S. Imes, HEATING, PIPING AND AIR CONDITIONING, November, 1934, pp. 467-470 and 77.



The *Queen Mary*, Cunard White Star's superliner, scheduled to sail from Southampton May 27 on her maiden voyage, arriving in New York June 1. Her main restaurant—"largest room afloat"—main lounge and her tourist class restaurant are air conditioned



Distillery Piping Requirements

. . .and how they were met at the world's largest distillery

[*By* B. C. Stewart*]

PIPING requirements of a distillery are distinctive in that extraordinary precaution must be exercised in laying out the piping system and in its operation to guard against bacteria invasion. The fermentation process is a bacterial action, but this must be kept under very positive control in order to insure the purity of the product. Not only must the entire plant be kept clean in the ordinary sense, but all receptacles and pipe lines must be chemically clean; this requirement when interpreted in details of construction is not so simple to carry cut as might at first be thought.

Another requirement peculiar to distilleries is the provision for government inspection and control of the handling of all materials. This is seen to be a major item in piping design when it is realized that every receptacle, every valve, and every joint in pumps, packing glands, valve bonnets and pipe lines must be equipped either with a lock or a seal in such manner that there is no possibility of moving or losing any of the product without the knowledge and presence of the government inspector.

How these and other distillery piping requirements are met is our subject here, the new plant of Hiram Walker & Sons, Inc., at Peoria, Ill., serving as an example.

This plant is of interest on several counts. Not only is it the largest distillery so far completed, but the individual units comprising the various processes are also of unprecedented size in practically all departments. The project was completed in a very brief period; construction was started in October, 1933, and the distillery went into operation June 1, 1934. That the plant could be started in this short time is noteworthy because a distillery must function in all departments before any part of it can be started up, for the time element is an essential feature of practically all processes, and also government regulations require that grain once weighed out of the bins must pass strictly on schedule through all the intermediate processes to the barrelling off of the finished product.

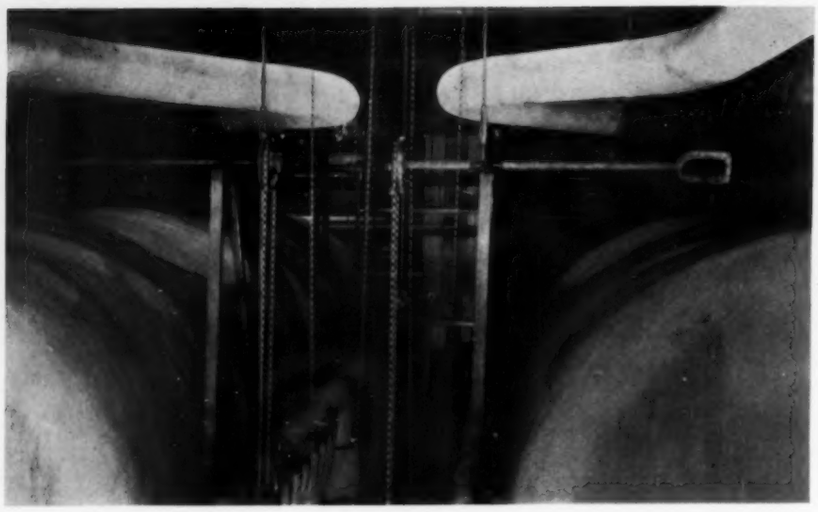
It is therefore apparent that only minor adjustments can be made after such a plant is placed in operation. This fact presented considerable difficulty in starting the new plant, in which much of the equipment is of new and untried design and some of it frankly experimental; however, including the first day of operation the Walker distillery has not had a shut-down due to failure of equipment to function; in fact, it has not been shut down for any reason except on the days stipulated by government regulations.

The Walker distillery is of entirely new construction; thus the designers were not hampered by the necessity of adaptation to existing buildings or equipment. This made possible the adoption of modern methods throughout and a grouping of buildings to the best possible advantage in the handling of raw materials, materials in process, and the finished product. Naturally, full advantage was taken of the latest knowledge and developments in the choice of materials of construction. While some of the equipment is of new design, conservatism was the attitude adopted in the selection of materials where any doubt at all existed. Pipe lines are in general of materials which have been used for many years in the industry.

The Distillery Process

In outline, the distillery process is quite simple. Corn, barley, rye, rye malt, barley malt, yeast, wort and water

*Smith, Hinchman & Grylls, Inc., Architects and Engineers, Detroit, Mich.



LEFT TO RIGHT

The grain after being ground is cooked in pressure cookers, the product being known as mash

The mash is run into fermenting tubs, yeast is added, and fermentation converts the malt into beer . . .

The beer is distilled, producing alcohol or whiskey, with fusel oil and aldehydes as byproducts, and spent beer as a residue

are the raw materials. The grain is ground, mixed according to various formulas, and cooked in pressure cookers, the product being known as mash, and having a consistency similar to thin gruel. The mash is run into fermenting tubs, yeast is added, and fermentation allowed to continue for about 72 hours, converting the malt into beer. The beer is distilled, producing alcohol or whiskey, with fusel oil and aldehydes as byproducts, and spent beer (now called "slop") as a residue. The whiskey comes from the stills at high proof, and is rectified to the desired proof by the addition of distilled water. Industrial alcohol is produced at still higher proof, and is generally sold at the proof at which it is produced, as are also the fusel oil and aldehydes. The slop is discharged from the still and passed over screens to remove the coarse grains, through centrifuges which throw out the finer solids, and is then evaporated; thus all of the grain, with only the starch and sugar removed, is recovered, dried in a rotary dryer, and sold as stock feed.

In detail, however, the equipment for carrying on the various processes as outlined above is in some departments quite complicated. All materials must be very carefully controlled as to quantities, time and temperature, and utmost precaution must be exercised in the matter of cleanliness to prevent the invasion of uncontrolled bacteria.

In a distillery, as in most chemical plants, the piping is a very vital part of the equipment. The piping services, material used and maximum size for the Walker plant piping are listed in Table 1.

The Service Piping Systems

Water—A large quantity of pure cold water is required for the process, and is supplied by four wells on the property, three of which are equipped with 2,000 gpm and one with a 3,000 gpm centrifugal deep well pumps. The water strata underlying the property has a depth of about 20 ft, the bottom surface of which is 63 ft below grade. The abundance of the water supply is indicated by the fact that the draw down in the wells when pumping full capacity is never greater than 5 ft. The water is very hard, which is desirable for the production of beer, but introduces difficulties when used for cooling and condensing and for boiler feed. For certain cooling processes, and for all of the condensers, the water is treated with sulphuric acid to convert the temporary hardness into permanent hardness, thus avoiding the deposit of scale in the cooler and condenser tubes. For boiler make-up, the water is given a lime and soda ash treatment in a hot process water softener.

City water is used for fire protection only, the system consisting of yard hydrants and a sprinkler system in all of the buildings, with the exception of the power house.

Gas—Gas is used as emergency boiler fuel, and at such times as the boilers are operating at very low ratings (Sunday load in summer months). Gas is purchased and metered at high pressure, 20 lb gauge, and reduced to 8 oz pressure for distribution to the boilers. In addition to the use as boiler fuel, a small amount of gas is used in the laboratories, of which there are three.

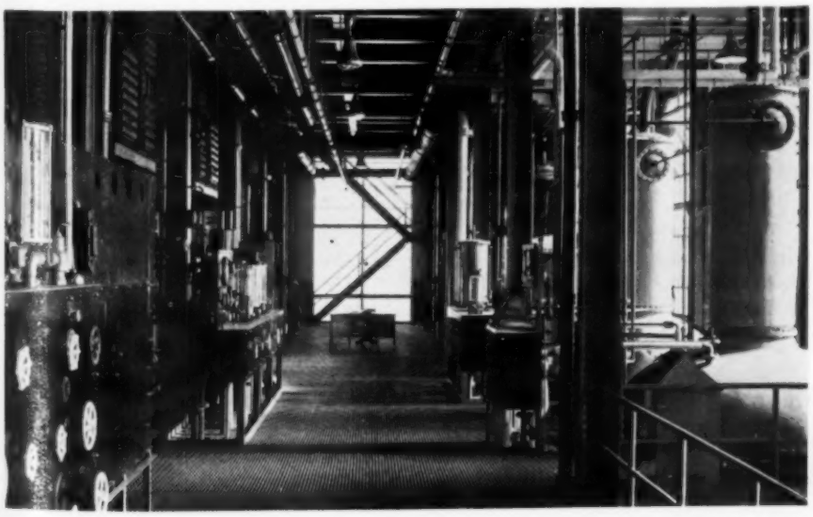
Hot Water—In the distillery processes, there is a large amount of waste heat rejected by the condensers, cookers, etc., and a great deal of heat generated in the fer-

menters and rejected by means of cooling coils. This waste heat is utilized for heating water for all processes, and for boiler feed. Hot water is required at temperatures of 90, 140 and 200 F, and there is therefore a separate hot water system for each of these temperatures. This water is stored in surge tanks in the mill and still buildings from which it is drawn as required by the various processes. Small heaters are provided to supplement the hot water supplies, but these are usually in service only during starting periods.

Air—The principal use of compressed air is for actuating thermal control devices for regulating the amount of cold water circulated through mash coolers and fermenting tanks.

Steam—The power plant, which furnishes all of the electric power and process steam, consists of two boilers supplying 250 lb steam to two 1500 kw turbines, from which steam is bled at 75 lb and which exhaust into the 15 lb steam main. The turbine generators are interconnected with the local utility system and generate only such power as is incidental to the production of the required amount of steam; thus no steam is wasted by going to condensers or by exhausting to atmosphere. The steam and power balance is such that during the six working days of the week enough power is fed into the utility's lines to pay for the power purchased from the utility on week-ends when the power plant is shut down. The pressure at the turbine bleeder nozzle and also at the exhaust is automatically regulated within very close limits so that full steam pressure at both 75 lb and 15 lb is maintained at all times, subject only to the limit set by the capacity of the generators. Peak steam demands beyond the capacity of the turbines to supply are taken care of by reducing valves and desuperheaters reducing the 250 lb, 500 F steam to 75 or 15 lb saturated steam as required.

The steam distribution system consists of a 75 lb main extending from the power house through an overhead enclosed bridge to the mill, still, fermenter buildings only, and a 15 lb main extended by a combination overhead and underground system to all of the buildings on the property. Some 15 lb steam is used in the processes in the mill, still, fermenter building, but most of the 15 lb steam is used for heating after being still further reduced in pressure at the point of use.



Piping is a very vital part of the equipment in a distillery, and the requirements which must be met present a number of problems. Contamination must be guarded against..... government inspection and control must be provided for.....the right material for the service must be selected. The new plant of Hiram Walker & Sons, Inc., illustrates this outline of distillery piping requirements

The Process Piping Systems

No particular problems or difficulties presented themselves in the design and layout of the service piping systems described above. However, with the process piping systems special problems were encountered in every case.

Grain—This plant consumes an average of 20,000 bushels of grain per day, all of which is received in railroad cars which are unloaded by a pneumatic system located in the top (7th floor) of the mill building. There are two unloading systems, either of which discharges at any one of eleven storage bins so that two different kinds of grain may be unloaded simultaneously. The grain piping is standard steel pipe with welded joints. At the intake end is connected two flexible metal vacuu hose so that grain is taken from both ends of the car simultaneously. The lower end of the steel pipe is of telescopic construction so that the intake nozzles may be raised or lowered at will in order to get at the different parts of the car. The steel pipe stands up under this highly abrasive service very well, but the flexible metal hose lasts for but a short time. Experiments are being made on the use of a rubber lined hose, but it has not yet been determined whether rubber lined or metal hose is the more desirable. The grain is separated from the air in cyclones and distributed to the bins by screw conveyors.

Meal—Grain flows by gravity from the grain bins occupying the 4th, 5th and 6th floors of the mill building to twelve mills on the ground floor. The meal discharged from the mills is again elevated to the 7th floor by a pneumatic system and distributed to meal bins occupying the 5th and 6th floors in the mill building. The meal vacuum system is also in duplicate so that two kinds of grain may be ground simultaneously. In the case of grain, filters are used instead of cyclones for separating the air from the meal. Distribution is taken care of by screw con-

veyors similar to those used for distributing the grain.

The meal is distributed to the cookers by an automatic system of scales, screw conveyors and piping controlled by a system of time and sequence relays, all controlled from the third floor, which is the cooker operating room. The method by which this automatic control works is roughly as follows:

The operator sets up on a dial the formula which he wishes to use—so much corn meal, so much water, barley malt, additional water, etc. He then opens an inlet cock to the cooker which operation starts and automatically controls a series of operations consisting of starting of the appropriate conveyor, opening of the proper gates, and starting of the desired automatic scale. When the required weight of meal has been fed through the scale, the gate automatically closes, the conveyor moves for a predetermined interval to transport all of the weighed grain to the cooker, and the conveyor then shuts down automatically. The process then repeats, weighing out and introducing into the cooker the required amount of the next constituent.

Bottling at the Walker plant

A detailed description of this automatic meal handling and measuring system is beyond the scope of this article. There is one feature, however, which is of interest to piping engineers, and that is the design of the meal intake cocks to the cookers, of which there are one 6 in. and one 8 in. size on each one of the eight cookers. The 6 in. cock admits so-called "wet" grain, and the 8 in. cock admits dry grain. Both cocks are subjected to a temperature fluctuation during each cooking process from 135 F to 320 F, and as previously stated, are operated by hand. The pressure range varies from 75 lb pressure to 27½ in. vacuum. Under all of the above conditions, the cock must be tight, and it is opened and closed about twelve times per day. These cocks are of brass with free opening the full size of the pipe. The plugs are made extra long and large in proportion to the size of the bore to provide plenty of bearing surface, and are equipped with a yoke and a screw concentric with the stem with a nut bearing against the shoulders on the yoke. By this means, the plug is lifted from its seat a few thousandths of an inch so that it will turn freely. The plug is then rotated to the open or closed position as desired, and the plug is reseated by the same lifting mechanism. A limit device on the unseating screw prevents the plug from being moved far enough off its seat to permit meal to get between the plug and the body.

It may be frankly stated that the designers hoped rather than expected that this device would operate in service, but these cocks have functioned surprisingly well considering the temperature and pressure conditions and the character of the material handled. After a period of several weeks a deposit of grain which has to be removed does build up in the plugs and the cock body, but this is the only difficulty so far experienced with these especially constructed cocks.

Mash—The mash, as mentioned, is a mixture of cooked grain and water of about the consistency of thin gruel. A requisite in the handling of mash in pipe lines is that it must be kept moving or the solids will settle out at low points in the line and in a few moments will solidify so that flow cannot be resumed. For this reason, the mash lines are laid out to avoid as much as possible any low points in the system, and where such occur, drain lines are provided. The entire mash piping system is of 4 in. copper tubing with stream-line soldered fittings. Cocks are used throughout instead of valves, the reason being that any depression in the pipe lines, such as a valve seat recess, would retain some of the solid material which could not be successfully removed by washing, thus providing a breeding place for unwanted bacteria. Wherever a cock was required in a horizontal run of pipe, it was necessary to make it of special design. The plug is placed off center so that with the plug horizontal the bottom of the plug seat is exactly level with the inner bottom surface of the pipe. Thus when the cock is opened, there are no pockets either in the cock itself or in the pipe on either side of the cock.

As has been stated, the utmost precaution must be taken for cleanliness, and it is therefore necessary to wash and sterilize thoroughly all of the mash lines immediately after use. Connections are provided at the high points in the piping system for hot water and steam. After a pipe line has handled a batch of mash, it is immediately followed by sufficient hot water thoroughly to flush out the pipe, after which the line is thoroughly steamed out for purpose of sterilization.

Yeast—The requirements for and construction of the yeast lines are similar to those for mash, except that the yeast lines are made with quick detachable union joints so that the entire piping system can be quickly dismounted to facilitate a thorough cleaning and more positive sterilization than is required for mash.

Beer—The beer as it comes from the fermenting tanks is discharged through a 12 in. cock of a design similar to the meal cocks described above, from which it flows through open troughs into a beer well. The beer as it leaves the fermenters and is stored in the beer well is at a temperature of about 85 F and is called cold beer. At

this temperature it may be handled in steel or wrought iron piping. The dump troughs and beer wells are all of copper bearing steel, and the pipe lines from the beer well to the beer-slop heat exchangers are of wrought iron. Beyond the heat exchangers the temperature of the beer is approximately 180 F and must be handled in copper piping, the construction of which is similar to the mash lines.

Slop—The spent beer or slop lines are of the same materials and construction as the mash lines. The slop is more acid than the mash or beer, and it was therefore necessary to use a special solder for making up the stream-line joints.

Concentrated Slop—The concentrated slop referred to in Table 1 is the residue coming from the evaporators in which the strained slop is disposed of. This concentrated slop is called syrup, and will flow through the pipe line only when kept hot. The pumps which handle this material are steam jacketed, and the pipe lines are heavily insulated to prevent freezing, which takes place at a temperature of about 100 F. This material is handled in ordinary steel pipe.

Vapor Vents—The slop is discharged at high temperature onto screens in the dryer house in which most of the water is removed, the grain discharged from the screens being still further dried by passing through presses. The vapor rising from the screens and presses collects in hoods made of asbestos board and is discharged through the roof through asbestos protected metal flues. It is essential that this vapor be kept out of contact with metal as it has a very corrosive effect and ordinary paint is not a sufficient protection against oxidization.

Carbon Dioxide—The fermentation process which takes place in the fermenter tubs produces a very large quantity of carbon dioxide gas. The pressure maintained in the closed fermenters is about 30 in. of water, and the gas is handled in standard weight steel piping, the valves being low pressure type gates. The gas is accumulated in one 12 in. main and conducted to a separate building on the property where a portion of it is manufactured into solidified carbon dioxide, or dry ice. The dry ice plant has a capacity for handling but a part of the total gas produced, and is operated in the summer time only, the excess gas being discharged through an underground line made of vitrified crock, which discharges the gas to the atmosphere at the river surface.

Distilled Water—All of the distilled water used in rectifying spirits is produced in the plant in stills located in the still building and the bottling building. Since distilled water is a very powerful solvent, and since alcohol and whiskey must be kept free of any trace of iron, the distilled water lines are of tin lined copper throughout; all pumps, valves and fittings also are tin lined.

Alcohol—Insofar as piping requirements are concerned, this heading includes also whiskey, gin, or any other product intended for beverage purposes. Alcohol is pumped from the stills to the high wines building where it is stored in tin lined copper tanks, thence to the shipping cistern building where it is rectified and barrelled. The requirements for alcohol piping are the same as for distilled water, except that an additional provision has to be made to conform to government regulations for the sealing of the lines. All valves are equipped with locks so that the operation of the piping system may be carried on under government supervision, and all pipe line unions, pumps and other connections are equipped with government seals so that no pipe line can be opened without the breaking of the seal, which must be done in the presence of a government inspector. The alcohol piping system is so arranged that the product of any still can be discharged into any one of the numerous storage tanks, this being effected by the use of manifolds. Another requisite of the alcohol pipe lines is that an entirely separate system of storage tanks and piping is required for gin, because the characteristic gin flavor would contaminate any other product if handled in the same equipment.

Industrial Alcohol—Industrial alcohol is produced at a higher proof than whiskey, and may be handled in steel piping; otherwise the requirements are the same as for other alcohols.

Fusel Oil and Aldehydes—These byproducts are marketed as produced, and are handled in unlined copper tubing.

[The piping contractor for this installation was the American Power Piping Corp., of St. Louis.]

Table 1—Piping Services at Walker Distillery

Service	Materials	Maximum Size, In.
Underground service:		
Well water	Cast iron and lead	20
City water	Cast iron	10
Gas	Steel	8
Sprinkler system	Cast iron	10
Service piping:		
Well water	Steel and copper	12
City water	Steel	10
Gas	Steel	8
Sprinkler lines	Steel	6
Hot raw water	Steel	12
Soft water	Steel	8
Compressed air	Galv. steel	4
Condensate	Steel	8
Steam at 250 lb, 500 F	Steel tubing	12
Steam at 75 lb	Steel	12
Steam at 15 lb	Steel	20
Steam vents	Spiral riveted	24
Pulverized coal	Steel	16
Soda ash and lime solution	Wrought iron	2
Sulphuric acid (concentrated)	Wrought iron	1
Sulphuric acid (dilute)	Lead	1
Waste	Steel, C. I., duriron,	16
	Crock	24
Process Piping:		
Grain	Steel, corr. flex	8
Meal	Steel	12
Mash	Steel—rubber	4
Yeast	Copper—rubber	4
Wort	Copper—rubber	2
Cold beer	Wrought iron	6
Hot beer	Copper	6
Cold slop	Wrought iron	6
Hot slop	Copper	6
Concentrated slop	Steel	4
Vapor vents	Asbestos and asbestos protected metal	36
Carbon dioxide	Steel	12
Distilled water	Tin lined copper	2
Alcohol	Tin lined copper	2
Industrial alcohol	Steel	2
Fusel oil, aldehydes	Copper	1

Practical Piping Problems

Conserves Compressed Air for Sewage Ejection by Taking Tip from Ancient Greek

By **H. G. Schaefer**

ARCHIMEDES, the Greek philosopher, was once greatly concerned in the development of water pumping equipment for irrigation purposes. His first offering was the historic water screw. Next came the application of compressed air to the pumping problem.

He piped an air jet to the base of a vertical pipe, submerged in the water source, and carried to the level of the irrigation ditch to be supplied. When compressed air was injected into the water, the bubbles expanded in their upward journey in inverse ratio to the pressure existing at the particular level at which they happened to be. With the expansion of the bubbles, the displaced water was pushed upward, without upsetting the static head at the base of the riser, and was eventually slopped over the top of the rising line into the ditch. With this discharge, base pressure was relieved to the extent that permitted the replenishment of the supply from the river or pond.

Once in a great while it is given us to observe the fruits of the application of brains to the solution of our problems. The case in point is that of the conservation of compressed air for sewage ejection.

The air requirements for a particular installation to lift sewage 65 ft were over 10,000 cu ft of free air, compressed to 34 lb per sq in. gage, per hr—quite an appreciable power and maintenance item. A chap who was wise enough to appreciate what our old Greek friend had done, cut in a few inexpensive gadgets, as indicated in the accompanying illustration, and now the compressor has a comparatively simple time in keeping up with the demand, and current, oil and water costs are correspondingly reduced.

The normal cycle of the ejectors, assuming that they have just been discharged, and that the static head of the sewer line is bearing on the discharge check valve, starts by the vent valve opening and relieving the internal air pressure to the vent line. Sewage then flows into the ejector chamber by gravity. When the chamber has been filled, the float controlling its operation first closes the vent valve, and then opens the compressed air supply valve. As the pressure builds up, the sewage first begins to back up in the sewer line, thus closing the inlet check. As the pressure reaches the point necessary to overcome the head on the disc of the discharge check, plus that required to overcome the inertia of the column and to start it moving, the contents of the ejector chamber are forced upward through the discharge pipe.

Obviously, when the chamber has been emptied, it must be vented to relieve the air pressure so that it may be re-filled. Equally obviously, the vented air represents a waste.

This galled the operating engineer, so he arranged to discharge the first stage of the vented air to the discharge riser, thus gaining the evacuation of a large portion of the contents thereof. When the point is reached at which the gradually reducing air pressure approaches the more slowly reducing static head pressure at the base of the riser, the air is diverted from the sewage riser and permitted to escape through the vent line.

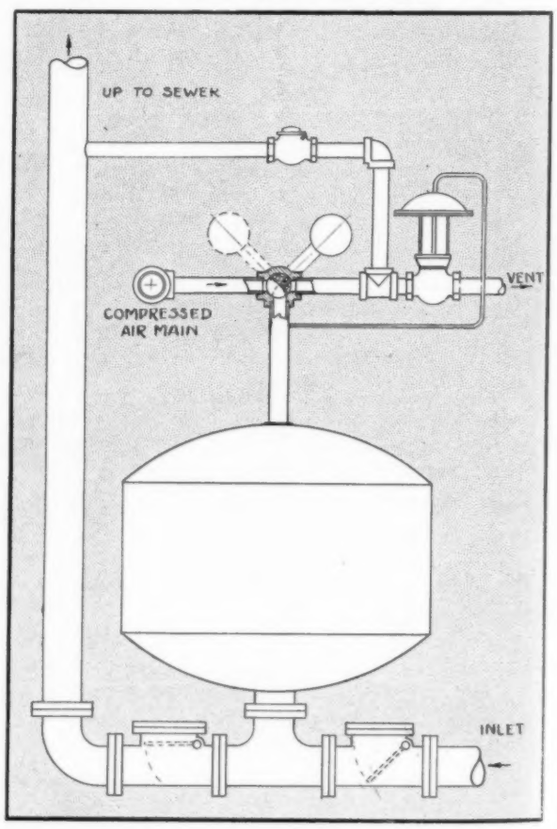
As soon as compressed air is admitted to the ejector it presses on the surface of the contents until the surface level has been depressed to its limit. The float within the chamber causes the supply to cut off, and the vent channel to be opened.

The spring loaded diaphragm valve is closed by the pressure existing within the ejector, which is communicated to the diaphragm chamber by the small air line shown. Since no other channel is available, the air passes through the swing check valve into the main sewage discharge riser.

The springs of the diaphragm valve are adjusted to open the valve when the air pressure falls to approximately 20 lb gauge. When this operation takes place, the swing check valve closes by the back pressure of air and sewage, and the remainder of the existing compression is exhausted to the atmosphere.

In the installation described, the actual savings in operating expense made through this improvement are in excess of one-fourth the original cost.

Piping arrangement that saves compressed air



How to Operate Oil Fired Heating Plants Efficiently

By **Paul R. Unger*** *and* **Kalman Steiner†**

THE material presented here is intended to serve as a general reference to the operating engineer in charge of oil fired equipment who desires to secure efficient performance of his equipment. It is also written for the engineer operating a plant equipped with the bare necessities for safe and continuous operation and interested in decreasing fuel costs further than can be done by careful supervision of operating equipment without benefit of adequate automatic combustion control. Perhaps some of the statements will seem trite and self-evident; however it seems advisable to err on the side of safety.

Cleanliness the Cardinal Virtue

Probably the cardinal virtue in any boiler room, and certainly with oil firing, is *cleanliness*. This is not intended as a remark about personal habits, but calls attention only to a technical feature concerning mechanical equipment handling fuel oil. Some believe that presence of oil at all points and places around the equipment is inevitable and merely in keeping with the nature of the stuff being handled. Happily, there are too many cases of well kept, bright and shining boiler rooms to permit this impression to become firmly established. Cleanliness in conjunction with oil burning is not only possible but is imperative to successful operation. And the things to be kept clean are not only those easily visible, but especially those that must be looked for and which are usually hidden from the casual observer.

Flues—Boiler flues are not part of the oil burning system; they must be kept clean regardless of the fuel used. Everyone likes to talk about the appalling fuel waste that occurs when boiler flues are dirty. A certain professor of engineering is frequently quoted as having stated that ⅛ in. of soot or scale has the insulating value of 2 in. of pipe covering. But it isn't necessary to quote statistics or to point with alarm. The authors are frequently asked, "How often should boiler flues be cleaned?" There is only one answer: "As often as necessary." And it should be remembered that improved technique in oil burner design is making possible the use of steadily increasing viscosities—what was called paving asphalt five years ago is today considered good fuel. This stuff has plenty of "heat" in it, and modern oil burners will get the heat out of it—but it must be expected that some soot will result. Here elbow grease or modern flue cleaning equipment must supplement the oil nozzles.

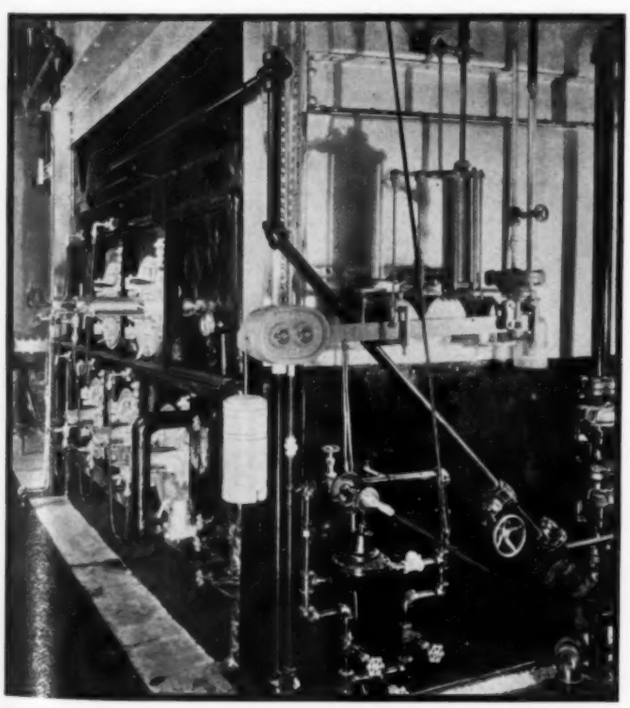


Fig. 1—Combination oil and gas fired boiler in a brewery, showing the hydraulically operated combustion control equipment and the burners. Note the cleanliness, which means efficiency

Strainers—Fouled oil strainers do not directly affect economy of operation, except that power costs for pumping will increase somewhat as the pressure drop through the strainers increases because of fouling. Duplicate oil strainers, as are usually provided in modern plants, facilitate cleaning by making possible continued operation through one set while another is being cleaned. Most operating men simply immerse the fouled strainer mesh or basket in kerosene and let it soak for a while. Others will send high pressure steam through it. As good a way as any is to wash the strainer mesh in gasoline, allowing most of the sediment to loosen and fall into the bucket; afterwards the surplus gasoline that clings to the mesh can be whisked off.

Burner Nozzles and Tips—Fouled burner nozzles and tips are another story. Sometimes their presence is immediately manifested by smoky fires or diminished steam pressure, but such visible indications of dirty oil nozzles occur usually only when the condition is aggravated. Anybody can then proceed to the cleaning job. It is far better practice to make inspections or cleanings sufficiently often, at regular intervals, so as to avoid the extremes of nozzles so badly fouled as to smoke up the

*Mid-West Heat Service Co., Chicago, Ill.
†Ace Engineering Co., Chicago, Ill.
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fires and cause pressure to drop. Usually extra nozzle tips and atomizers are inexpensive, so that a few spares can be kept on hand. It is then very simple to place a fresh nozzle on the burners and clean the one so replaced when convenient.

Fans and Blower Wheels—Fans and blower wheels will not proclaim their fouled condition as readily as will nozzles. Here it is a case of gradually accumulating sediment deposits, along with grease and grime, laid down in such fashion as to slowly but surely reduce the flow of air. The consequences are of course poorer atomization and lowered combustion efficiency. Since these devices are wholly enclosed in casings of some sort, only an inspection which involves opening the casing will reveal the true story. Experience will, in any given plant, indicate how often such inspections should be made and how often it is likely that cleaning of the fan wheels will be needed. Probably this operation is one of the most neglected matters in the routine of plant maintenance. It does not take much accumulation of dirt in a fan to knock combustion efficiency off a few points, and it does not take much time or effort to pull a blower housing apart to have a look. Here is a case where a wrench makes an excellent fuel saver.

Oil Heaters—Oil heaters can be said to have this distinction: They are the only pieces of oil burning apparatus creating their own sediment. Oil heaters are, in general, constructed like water heaters in that heat must be exchanged from one medium—steam, hot water, or an electric heating element—to another medium. But manufacturers of oil heaters usually design for a higher rate of fluid flow over the heat exchange surface; this usually means that the oil passes through a series of narrow tubes, where in the case of water heating the water would probably pass over the tubes and the steam or hot water through them. The result is that sediment formation on the heating surface has a twofold effect; it retards the flow of oil as well as the transfer of heat. In other words, as a fuel oil heater becomes dirty, it heats less oil through a smaller temperature rise. The sediment formation may in part be due to deposits brought in originally with the fuel oil, but largely it is caused by the action of heat on the oil, the heavier hydrocarbons being decomposed to form free carbon and lower weight hydrocarbons. This free carbon clings to the tube surface as a scale.

The reduced capacity of a fuel oil heater will not affect operation so long as the fuel is heated above the critical temperature of the oil viscosity, which is the temperature at which the oil viscosity breaks sharply to a minimum below which it does not drop appreciably on further heating. But once the oil fails to attain this temperature trouble may be expected at the burners. Of course, where electric heaters are placed after the steam heater, then any deficiency in temperature as the oil leaves the steam heater is automatically imparted by the electric heater which is cut in by its thermostat to make up the temperature deficiency. Continued use of the electric heater causes high electric energy consumption and when both steam and electric heaters are fouled badly enough, then preheating of the fuel becomes inadequate and high viscosity oil begins to reach the nozzles. This means poor atomization and loss of efficiency, which in turn mean high fuel consumption and possible difficulty in holding the load.

If straight tube heaters with external oil and steam connections are used, the heads may be removed and the tubes rodded without breaking either oil or steam connections. Fig. 2 shows a method of cleaning high pressure steam oil preheaters without removing the heads. By piping steam into the oil inlet to the heater and washing the discharge to the sewer as shown, steam can be blown through the oil passes at regular intervals and the heater thus kept clean; this is done by closing valves *1*, *2* and *3*, opening heater bypass valve *4*, and opening valves *5* and *6* blowing steam through the heater.

Storage Tank—Whether or not it saves money, the fuel oil storage tank can be and should be kept clean. Ordinarily, this is accomplished when the fuel is supplied in tank truck deliveries by having the fuel company pump out sediment deposits at periodic intervals. And the money part enters here, too—most oil companies will allow full credit for each gallon of sediment thus removed. When fuel is purchased in carload lots, then other provision must be made for cleaning out tanks. By running the tank contents low, *i. e.*, burning up as much as possible, and then opening the manhole, accumulated sediment can be removed in buckets when no special pumping equipment is available for this. Many modern plants are today provided with two suction stubs in each tank, one about 3 in. from the bottom of the tank and the other 5 or 6 in. higher. When the gradual accumulation of sediment reaches the lower suction stub, it is cut out of service. Oil to supply the burners is pulled from the high line until the sediment is removed through the lower stub or by some other method. Some plants with duplicate pumps are arranged so that sediment can be removed through the low suction stub with one pump while the other one feeds the burners.

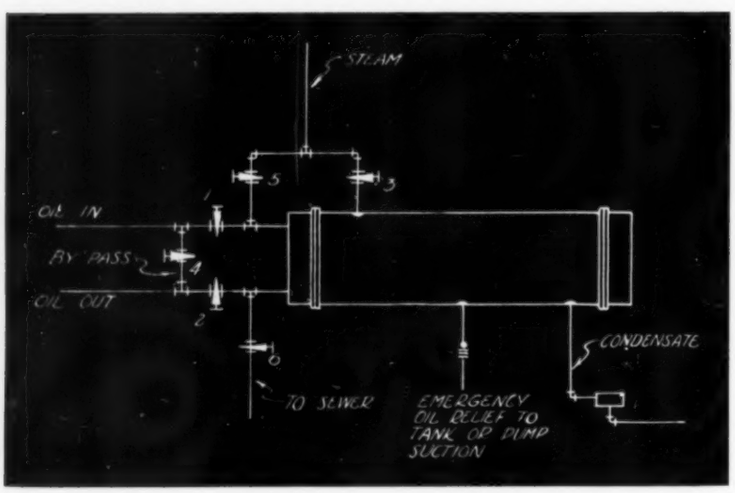


Fig. 2 — Oil preheater valved for cleaning without removing the heads. By closing valves 1, 2 and 3 and opening valves 4, 5 and 6, steam is blown through the heater to keep it clean

It should now be obvious that it pays to clean up; it certainly pays equally well, if not more so, to check

up on the performance of the equipment. This check-up should have two objectives: To assure that safety devices are in proper working order, and to assure that all elements affecting combustion efficiency are under control.

Check Performance of Safety Devices

The safety devices customarily provided in an oil fired boiler plant protect against low water in boilers, failure of combustion or interruption of oil supply to nozzles, excessive boiler steam pressure, fire hazard from oil vapors in tanks or oil leaking from the pumping and piping system. Low water protection embraces low water switches (which can be wired either to interrupt oil burner operation entirely or to sound or flash an alarm bell or light), water feeding apparatus (such as float valves to control direct admission of water to boilers and float switches to control feed pump operation) and electric wiring schemes to prevent burner operation if feed water pumps are not properly energized with electric power.

Float Operated Devices—Float chambers of all float operated devices, whether switches or valves, should always be equipped with blow down connections, and periodic blow downs should be made to keep the chamber clear of sediment and scale. Immediately after the original installation the float devices should be tested by lowering the water line to see that the float mechanism is free and functioning and that the desired operation is performed by the float at the correct water level. At reasonably frequent intervals thereafter—say every six months—the float operation should again be checked to assure perfectly free motion of the float mechanism. The floats themselves are usually copper spheres subject to corrosion so that sometimes the floats become perforated and water logged. Blowing down sediment and scale will assist in preventing corrosion.

Mercury Tubes—The electrical function of a float switch is usually accomplished through the medium of a mercury tube which occasionally will develop slight cracks in the glass, allowing air to enter the tube. The arc flash which accompanies each tripping operation, if air is present, will soon oxidize the mercury and cause it to cling to the electrodes. When this condition is aggravated the tube will fail to break contact when the tube trips to the "off" position, which would keep the burner running despite low water. Only an actual test of the device will reveal this condition, so it is good practice once a month to drop the water level to check the electrical cut-out. If the electric switch is the open contact type, then testing to guard against pitted contacts is equally important.

These remarks on failure of electrical switching apply also to pressurestats installed to prevent building up of excessive steam pressure on the boilers. The easiest way to test a pressurestat is to close the king valve on the boiler for the few moments required to allow steam pressure to reach the cut-out point. (*Caution:* When doing this be sure that the boiler water is not forced out through return connections!)

Relays—It should be noted that it is not sufficient merely to test the actual tripping of the mercury tubes in low water cut-outs or pressurestats and thus to observe that the mercury runs away from the electrodes to leave a clean separation that apparently opens the circuit. These safety devices almost always operate through intermediate relays that must in turn break the main electrical circuit. At times these relays stick in a closed position and thus fail to stop the burner even though the cut-out itself has functioned properly. The writers know of at least one case where a cast iron boiler was completely destroyed by a burner continuing to run after the low water cut-out was tripped properly; the motor starting relay had jammed in the closed position and did not stop the burner at all. *Always test these safety features when the entire plant is running normally, for only in this manner does the test prove positively that the burner will stop.*

Intended to serve as a general reference to the operating engineer in charge of an oil fired plant who desires to secure efficient performance of the system under his supervision, the material presented here contains suggestions on the maintenance and inspection of the various items of equipment, checking up on the performance of safety devices, and the importance of doing so . . . . Future issues will include information on combustion and the requirements for combustion efficiency. . . . . . .

With warm air furnaces, as commonly used for theater heating, the main electrical supply for the oil burners should be taken directly from the lower side of the ventilating fan switch; this assures that the burners cannot start until the fan is blowing air over the furnaces. This safeguard should be adopted even if there are also duct limit switches which operate to stop the burners when air temperatures are too high, for the time lag would be long enough to injure the furnaces before the limit devices acted.

Combustion safety switches are of two general types, manual and automatic. With the former, which is the more general in industrial work, the combustion switch must be manually closed to complete the circuit so that burners may be started. Then, should flame failure occur for any reason, the switch opens and interrupts the burner circuit. The cycle is repeated each time burner operation is desired. About the only maintenance required on this equipment is that the bi-metal helix or disc which is responsive to temperature changes must be kept clean of soot or carbon deposit so that its response to temperature changes will not be sluggish. Of course, the electrical features are subject to the same comments as already made above in connection with low water and high pressure.

As to the automatic combustion switch, while in general it serves the same functions, it must also control the ignition timing and so must be located and regulated so that it does not cut off the ignition too soon but rather delays this until the oil fire is established sufficiently to maintain itself after ignition cut-off.

(*Concluded on next page*)

Table of Properties of Pipe Aids Piping Design

THERE appeared with the article on support of industrial piping by F. L. Snyder* and T. E. Bridge†, published in the February, 1936, issue of HEATING, PIPING AND AIR CONDITIONING, a table of the properties of pipe. Because lack of space made it necessary to publish the table in a size too small for convenient use, and because many requests have been received for publication of these data in larger size, the information is again published this month. The values shown have been checked by the authors, as a few typographical errors were discovered, and the corrections have been made. Data on additional pipe sizes, including thin wall piping, have been included.

It is believed that this is the most complete table available on the physical characteristics of various pipe sizes, as it usually has been necessary to consult several different handbooks and to calculate many of the values. It has been found by the authors to be a considerable time-saver in industrial piping design work.

A similar table covering pipe sizes from 14 in. to 36 in. O.D. will appear in a later issue.

Formulas for values other than shown in the table:

$$I = 0.0491\ (D_1^4 - D_2^4) = AR^2$$
$$P = 2f\ (t/D_1)$$
$$Z = 0.0982\ (D_1^4 - D_2^4)/D_1$$
$$R = 0.25\ \sqrt[2]{D_1^2 + D_2^2}$$
$$Q = \text{Ft lb}/1000 = 2.25I/y = 4.5I/D_1$$

where

P = Ultimate bursting pressure, lb per sq in.
f = Fiber stress, lb per sq in.
A = Area of metal, sq in.
I = Moment of inertia of pipe section, inches fourth
Z = Section modulus, inches cube
R = Radius of gyration.

Q = Strength factor, representing the strength of the pipe to resist bending action. It is the resisting moment in thousands of foot pounds, the stress in the material being 27,000 lb per sq in. For other allowable stress in the material the resisting moment is directly proportional.

y = Distance of farthest fiber from neutral axis = $D_1/2$.
D_1 = External diameter of pipe, in.
D_2 = Internal diameter of pipe, in.
t = Thickness of pipe walls, in.

Pipe Wall Thickness:

Minimum thickness of pipe wall at different pressures and for temperatures not exceeding 750 F for steel or wrought iron pipe; 406 F for brass and copper pipe; and 450 F for cast iron may be determined with Formula "I" of the *A.S.M.E.* Pressure Piping Code, in which

$$t_m = (PD/2S) + C \qquad P = (2S/D)\ (t_m - C)$$

where

t_m = Minimum pipe wall thickness, in.
P = Internal pressure, lb per sq in. gauge.
(Plus water hammer allowance in case of cast iron pipe conveying liquids.)
D = Actual outside diameter of pipe, in.
S = Allowable stress in material, lb per sq in.
C = Factor for allowance for threading, mechanical strength and/or corrosion.

C VALUES

Material	*C Factor*
Cast iron pipe	0.14
Cast iron pipe pit cast	0.18
Threaded steel or wrought iron	Depth of thread
Grooved steel or wrought iron	Depth of thread
Plain end steel or wrought iron 1 in. and smaller. (Plain end includes pipe joined by flared compression couplings, laps, or van stone joints, and by welding)	0.05
Plain end steel or wrought iron sizes above 1 in. (Plain end includes pipe joined by flared compression couplings, laps, or van stone joints, and by welding)	0.065

S VALUES

Material	*Values of S*
Steel pipe seamless Grade "C" (*A.S.T.M.* A-106)	14000
Steel pipe seamless Grade "B" (*A.S.T.M.* A-106 & A-53)	11500
Steel pipe seamless Grade "A" (*A.S.T.M.* A-106 & A-53)	9000
Steel pipe lap-welded (*A.S.T.M.* A-53)	7000
Wrought iron pipe lap-welded (*A.S.T.M.* A-72)	5300
Wrought iron pipe butt-welded (*A.S.T.M.* A-72)	4500
Brass pipe seamless (*A.S.T.M.* B-43)	4500
Copper pipe seamless (*A.S.T.M.* B-42)	4000
Copper tubing seamless (*A.S.T.M.* B-75 & B-88)	4000
Cast iron pipe (*F.S.B.W.W.* P-421)	6000
Cast iron pipe pit cast (*A.W.W.A.*)	4000

[*Continued on next page*]

*Engineering Department, E. I. duPont de Nemours & Co., Inc., Wilmington, Del. Member of Board of Consulting and Contributing Editors.
†Engineering Department, E. I. duPont de Nemours & Co., Inc., Wilmington, Del.

How to Operate—

(*Concluded from preceding page*)

Stack Switches—With stack switches again we have the same story—keep them clean. Stack switches are intended primarily to prevent oil flooding of the boiler or pumping of oil into the firebox when combustion is not occurring. Ultimately, should flooding occur, oil would run back out of the boiler into the boiler room, and cause a fire hazard. Similarly, any oil escaping from pipes or pumps because of leaks or loose packing joints or connections will also constitute a potential fire hazard, especially if the oil temperature is near the flash point. Many localities have ordinances requiring that a fire extinguisher be kept in the boiler room; even in the absence of such legal stipulations, an extinguisher should certainly be on hand, and should be regularly inspected for operating order.

The inside of a steel oil storage tank is not ordinarily considered as a spot to look for fire hazard, for certainly oil cannot start to burn when so confined. But the vapors above the liquid in the tank are another story. All tanks are of course vented to atmosphere, and so the oil vapor above the liquid oil is mixed with air. When there are steam coils in the tank, a certain portion of a coil becomes exposed to the vapors as the liquid level falls. As the flash point of most heavy fuel oils is not much higher than 250 F, it can be seen that it does not require a very high pressure in the steam coil to attain this flash temperature. (The temperature of steam at 15 lb gauge pressure is 250 F; at 50 lb gauge the temperature is 298 F.) Hence, it is only common sense that some means be made available against emergencies arising from this situation. Steam smothering lines are the most logical system, as nothing will extinguish an oil fire more quickly or effectively than will live steam.

[The authors' next article explains in unusual manner the process of combustion, the requirements for combustion efficiency and how they may be attained.—THE EDITOR.]

Table of Properties of Pipe—continued

Properties of Pipe
Commercial Pipe Sizes, ⅛ in. to 12 in.

Nom. Pipe Size	Outside Diam.	Inside Diam.	Wall Thickness	Wt. per foot	Wt. of Water per Ft. Pipe	Sq.Ft. Outside Surface per ft.	Sq.Ft. Inside Surface per ft.	Transverse Area Sq.In.	Area Metal Sq.In.	Moment of Inertia	Section Modulus I/y	Radius Gyration Squared	Radius Gyration	ULTIMATE BURSTING PRESSURE* Butt-Weld	Lap-Weld	Hammer Weld	Seamless & Line Weld	Strength Factor Q 1000 ft.lb.
1/8	.405	.269	.068	.244	.0246	.106	.0705	.0568	.072	.00106	.0053	.0148	.1215	13400	-	-	22000	.01182
"	"	.215	.095	.314	.0157	"	.0563	.0364	.0925	.00122	.006	.01314	.1146	18800	-	-	28100	.01351
1/4	.540	.364	.088	.424	.0451	.141	.0955	.1041	.125	.00331	.0123	.02651	.1628	13000	-	-	19500	.0276
"	"	.302	.119	.535	.031	"	.0794	.07163	.1574	.00378	.01395	.02393	.1547	17600	-	-	26500	.03138
3/8	.675	.493	.091	.567	.0827	.177	.1295	.191	.167	.0073	.0216	.04367	.209	10800	-	-	16150	.0486
"	"	.423	.126	.738	.0609	"	.1106	.1405	.2173	.00862	.o2554	.034	.1991	14900	-	-	22400	.05746
1/2	.840	.622	.109	.850	.1316	.220	.1637	.304	.2503	.0171	.0407	.0683	.2613	10400	-	-	15550	.09156
"	"	.546	.147	1.087	.1013	"	.1433	.234	.3200	.0201	.0478	.06273	.2505	14000	-	-	21000	.1076
"	"	.252	.294	1.714	.0216	"	.066	.04987	.5043	.02424	.05772	.04807	.2192	28000	-	-	42000	.1299
3/4	1.050	.824	.113	1.130	.2301	.275	.2168	.533	.3326	.03704	.07055	.1113	.3337	8610	-	-	12900	.1587
"	"	.742	.154	1.473	.1875	"	.1948	.433	.4335	.04479	.08531	.1033	.3214	11700	-	-	17600	.1919
"	"	.675	.1875	1.727	.1545	"	.1759	.357	.5081	.0495	.0943	.0974	.3121	14300	-	-	21400	.213
"	"	.434	.308	2.440	.0633	"	.1137	.1479	.716	.05792	.1103	.08068	.2840	23500	-	-	35300	.2482
1	1.315	1.049	.133	1.678	.374	.344	.274	.864	.4939	.08734	.1328	.1769	.4205	8100	-	-	12150	.2989
"	"	.957	.179	2.171	.3112	"	.252	.719	.6388	.1056	.1606	.1653	.4066	10900	-	-	16300	.3614
"	"	.8775	.21875	2.561	.2614	"	.229	.604	.7534	.1177	.1798	.1562	.3952	13300	-	-	19900	.4028
"	"	.599	.358	3.659	.1221	"	.157	.2818	1.076	.1405	.2136	.1305	.3613	21800	-	-	32700	.4807
1-1/4	1.66	1.38	.14	2.272	.6471	.434	.362	1.495	.6685	.1947	.2346	.2913	.5397	6750	8400	-	10100	.5278
"	"	1.278	.191	2.996	.5553	"	.3356	1.283	.8815	.2426	.2913	.2743	.5237	9200	11500	-	13800	.6555
"	"	1.16	.25	3.764	.4575	"	.3029	1.057	1.107	.2833	.3421	.2565	.5063	12000	15100	-	18100	.7696
"	"	.896	.382	5.214	.2732	"	.2331	.6305	1.534	.3411	.411	.2224	.4716	18000	23000	-	27600	.9247
1-1/2	1.900	1.61	.145	2.717	.882	.497	.4213	2.036	.7995	.3099	.3262	.3876	.6226	6100	7600	-	9160	.734
"	"	1.5	.2	3.631	.7648	"	.3927	1.767	1.068	.3912	.4118	.3663	.6052	8400	10500	-	12650	.9265
"	"	1.3375	.28125	4.862	.6082	"	.3519	1.405	1.43	.4826	.508	.3375	.5809	11800	14800	-	17800	1.143
"	"	1.1	.4	6.408	.4117	"	.2903	.9503	1.885	.5678	.5977	.3013	.5489	16800	21000	-	25300	1.345
2	2.375	2.067	.154	3.652	1.452	.622	.5401	3.355	1.075	.6657	.5606	.6196	.7871	5200	6500	-	7800	1.261
"	"	2.041	.167	3.938	1.42	"	.536	3.28	1.158	.71	.5979	.6129	.7829	5600	7000	-	8450	1.345
"	"	2	.1875	4.38	1.363	"	.5237	3.142	1.289	.7764	.6538	.6025	.7764	6300	7900	-	9800	1.471
"	"	1.939	.218	5.022	1.279	"	.5074	2.953	1.477	.8679	.7309	.5875	.7665	7340	9200	-	11000	1.644
"	"	1.875	.25	5.673	1.196	"	.492	2.761	1.669	.9555	.8046	.5725	.7565	8400	10500	-	12650	1.81
"	"	1.75	.3125	6.883	1.041	"	.4581	2.405	2.025	1.102	.928	.5442	.7376	10500	13160	-	15800	2.088
"	"	1.503	.436	9.029	.7686	"	.3929	1.774	2.656	1.311	1.104	.4937	.7027	14700	18400	-	22000	2.485
2-1/2	2.875	2.469	.203	5.793	2.072	.753	.6462	4.788	1.704	1.53	1.064	.8976	.9474	5650	7100	-	8500	2.394
"	"	2.441	.217	6.16	2.026	"	.6381	4.68	1.812	1.611	1.121	.889	.943	6000	7550	-	9050	2.521
"	"	2.325	.276	7.661	1.834	"	.6095	4.253	2.254	1.924	1.339	.8539	.9241	7700	9600	-	11500	3.012
"	"	2.125	.375	10.01	1.535	"	.5564	3.547	2.945	2.3527	1.638	.7993	.8938	10400	13000	-	15700	3.685
"	"	1.771	.552	13.69	1.067	"	.4627	2.464	4.028	2.871	1.997	.7126	.8442	15400	19200	-	23000	4.493

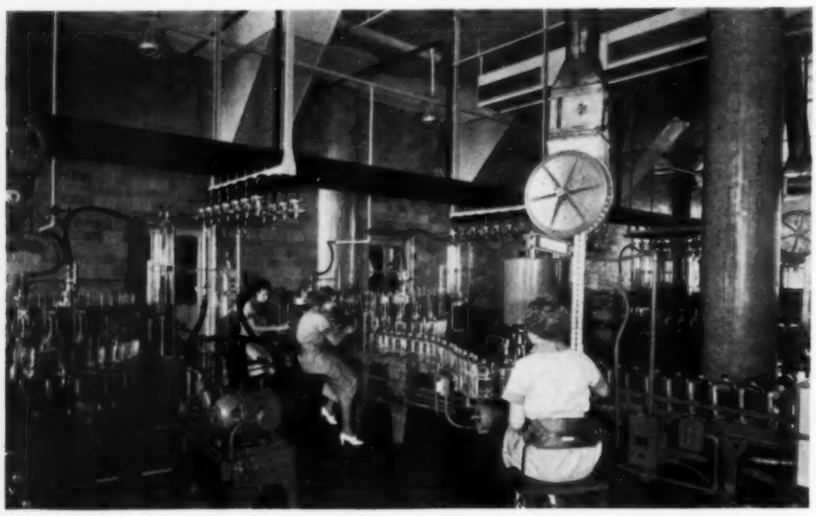
*Note: Butt-weld -- f = 40000 lb. per sq. in.
Lap-weld --- f = 50000 lb. per sq. in.
Hammer-weld--f = 45000 lb. per sq. in.
Seamless & Line-weld --
f = 60000 lb. per sq. in.

[Continued on next page]

veyors similar to those used for distributing the grain.

The meal is distributed to the cookers by an automatic system of scales, screw conveyors and piping controlled by a system of time and sequence relays, all controlled from the third floor, which is the cooker operating room. The method by which this automatic control works is roughly as follows:

The operator sets up on a dial the formula which he wishes to use—so much corn meal, so much water, barley malt, additional water, etc. He then opens an inlet cock to the cooker which operation starts and automatically controls a series of operations consisting of starting of the appropriate conveyor, opening of the proper gates, and starting of the desired automatic scale. When the required weight of meal has been fed through the scale, the gate automatically closes, the conveyor moves for a predetermined interval to transport all of the weighed grain to the cooker, and the conveyor then shuts down automatically. The process then repeats, weighing out and introducing into the cooker the required amount of the next constituent.



Bottling at the Walker plant

A detailed description of this automatic meal handling and measuring system is beyond the scope of this article. There is one feature, however, which is of interest to piping engineers, and that is the design of the meal intake cocks to the cookers, of which there are one 6 in. and one 8 in. size on each one of the eight cookers. The 6 in. cock admits so-called "wet" grain, and the 8 in. cock admits dry grain. Both cocks are subjected to a temperature fluctuation during each cooking process from 135 F to 320 F, and as previously stated, are operated by hand. The pressure range varies from 75 lb pressure to 27½ in. vacuum. Under all of the above conditions, the cock must be tight, and it is opened and closed about twelve times per day. These cocks are of brass with free opening the full size of the pipe. The plugs are made extra long and large in proportion to the size of the bore to provide plenty of bearing surface, and are equipped with a yoke and a screw concentric with the stem with a nut bearing against the shoulders on the yoke. By this means, the plug is lifted from its seat a few thousandths of an inch so that it will turn freely. The plug is then rotated to the open or closed position as desired, and the plug is reseated by the same lifting mechanism. A limit device on the unseating screw prevents the plug from being moved far enough off its seat to permit meal to get between the plug and the body.

It may be frankly stated that the designers hoped rather than expected that this device would operate in service, but these cocks have functioned surprisingly well considering the temperature and pressure conditions and the character of the material handled. After a period of several weeks a deposit of grain which has to be removed does build up in the plugs and the cock body, but this is the only difficulty so far experienced with these especially constructed cocks.

Mash—The mash, as mentioned, is a mixture of cooked grain and water of about the consistency of thin gruel. A requisite in the handling of mash in pipe lines is that it must be kept moving or the solids will settle out at low points in the line and in a few moments will solidify so that flow cannot be resumed. For this reason, the mash lines are laid out to avoid as much as possible any low points in the system, and where such occur, drain lines are provided. The entire mash piping system is of 4 in. copper tubing with stream-line soldered fittings. Cocks are used throughout instead of valves, the reason being that any depression in the pipe lines, such as a valve seat recess, would retain some of the solid material which could not be successfully removed by washing, thus providing a breeding place for unwanted bacteria. Wherever a cock was required in a horizontal run of pipe, it was necessary to make it of special design. The plug is placed off center so that with the plug horizontal the bottom of the plug seat is exactly level with the inner bottom surface of the pipe. Thus when the cock is opened, there are no pockets either in the cock itself or in the pipe on either side of the cock.

As has been stated, the utmost precaution must be taken for cleanliness, and it is therefore necessary to wash and sterilize thoroughly all of the mash lines immediately after use. Connections are provided at the high points in the piping system for hot water and steam. After a pipe line has handled a batch of mash, it is immediately followed by sufficient hot water thoroughly to flush out the pipe, after which the line is thoroughly steamed out for purpose of sterilization.

Yeast—The requirements for and construction of the yeast lines are similar to those for mash, except that the yeast lines are made with quick detachable union joints so that the entire piping system can be quickly dismounted to facilitate a thorough cleaning and more positive sterilization than is required for mash.

Beer—The beer as it comes from the fermenting tanks is discharged through a 12 in. cock of a design similar to the meal cocks described above, from which it flows through open troughs into a beer well. The beer as it leaves the fermenters and is stored in the beer well is at a temperature of about 85 F and is called cold beer. At

this temperature it may be handled in steel or wrought iron piping. The dump troughs and beer wells are all of copper bearing steel, and the pipe lines from the beer well to the beer-slop heat exchangers are of wrought iron. Beyond the heat exchangers the temperature of the beer is approximately 180 F and must be handled in copper piping, the construction of which is similar to the mash lines.

Slop—The spent beer or slop lines are of the same materials and construction as the mash lines. The slop is more acid than the mash or beer, and it was therefore necessary to use a special solder for making up the stream-line joints.

Concentrated Slop—The concentrated slop referred to in Table 1 is the residue coming from the evaporators in which the strained slop is disposed of. This concentrated slop is called syrup, and will flow through the pipe line only when kept hot. The pumps which handle this material are steam jacketed, and the pipe lines are heavily insulated to prevent freezing, which takes place at a temperature of about 100 F. This material is handled in ordinary steel pipe.

Vapor Vents—The slop is discharged at high temperature onto screens in the dryer house in which most of the water is removed, the grain discharged from the screens being still further dried by passing through presses. The vapor rising from the screens and presses collects in hoods made of asbestos board and is discharged through the roof through asbestos protected metal flues. It is essential that this vapor be kept out of contact with metal as it has a very corrosive effect and ordinary paint is not a sufficient protection against oxidization.

Carbon Dioxide—The fermentation process which takes place in the fermenter tubs produces a very large quantity of carbon dioxide gas. The pressure maintained in the closed fermenters is about 30 in. of water, and the gas is handled in standard weight steel piping, the valves being low pressure type gates. The gas is accumulated in one 12 in. main and conducted to a separate building on the property where a portion of it is manufactured into solidified carbon dioxide, or dry ice. The dry ice plant has a capacity for handling but a part of the total gas produced, and is operated in the summer time only, the excess gas being discharged through an underground line made of vitrified crock, which discharges the gas to the atmosphere at the river surface.

Distilled Water—All of the distilled water used in rectifying spirits is produced in the plant in stills located in the still building and the bottling building. Since distilled water is a very powerful solvent, and since alcohol and whiskey must be kept free of any trace of iron, the distilled water lines are of tin lined copper throughout; all pumps, valves and fittings also are tin lined.

Alcohol—Insofar as piping requirements are concerned, this heading includes also whiskey, gin, or any other product intended for beverage purposes. Alcohol is pumped from the stills to the high wines building where it is stored in tin lined copper tanks, thence to the shipping cistern building where it is rectified and barrelled. The requirements for alcohol piping are the same as for distilled water, except that an additional provision has to be made to conform to government regulations for the sealing of the lines. All valves are equipped with locks so that the operation of the piping system may be carried on under government supervision, and all pipe line unions, pumps and other connections are equipped with government seals so that no pipe line can be opened without the breaking of the seal, which must be done in the presence of a government inspector. The alcohol piping system is so arranged that the product of any still can be discharged into any one of the numerous storage tanks, this being effected by the use of manifolds. Another requisite of the alcohol pipe lines is that an entirely separate system of storage tanks and piping is required for gin, because the characteristic gin flavor would contaminate any other product if handled in the same equipment.

Industrial Alcohol—Industrial alcohol is produced at a higher proof than whiskey, and may be handled in steel piping; otherwise the requirements are the same as for other alcohols.

Fusel Oil and Aldehydes—These byproducts are marketed as produced, and are handled in unlined copper tubing.

[The piping contractor for this installation was the American Power Piping Corp., of St. Louis.]

Table 1—Piping Services at Walker Distillery

Service	Materials	Maximum Size, In.
Underground service:		
Well water	Cast iron and lead	20
City water	Cast iron	10
Gas	Steel	8
Sprinkler system	Cast iron	12
Service piping:		
Well water	Steel and copper	12
City water	Steel	10
Gas	Steel	8
Sprinkler lines	Steel	6
Hot raw water	Steel	12
Soft water	Steel	8
Compressed air	Galv. steel	4
Condensate	Steel	8
Steam at 250 lb, 500 F	Steel tubing	12
Steam at 75 lb	Steel	12
Steam at 15 lb	Steel	20
Steam vents	Spiral riveted	24
Pulverized coal	Steel	16
Soda ash and lime solution	Wrought iron	2
Sulphuric acid (concentrated)	Wrought iron	1
Sulphuric acid (dilute)	Lead	1
Waste	Steel, C. I., duriron,	16
	Crock	24
Process Piping:		
Grain	Steel, corr. flex	8
Meal	Steel	12
Mash	Steel—rubber	4
Yeast	Copper—rubber	4
Wort	Copper—rubber	2
Cold beer	Wrought iron	6
Hot beer	Copper	6
Cold slop	Wrought iron	6
Hot slop	Copper	6
Concentrated slop	Steel	4
Vapor vents	Asbestos and asbestos protected metal	36
Carbon dioxide	Steel	12
Distilled water	Tin lined copper	2
Alcohol	Tin lined copper	2
Industrial alcohol	Steel	2
Fusel oil, aldehydes	Copper	1

Practical Piping Problems

Conserves Compressed Air for Sewage Ejection by Taking Tip from Ancient Greek

By **H. G. Schaefer**

ARCHIMEDES, the Greek philosopher, was once greatly concerned in the development of water pumping equipment for irrigation purposes. His first offering was the historic water screw. Next came the application of compressed air to the pumping problem.

He piped an air jet to the base of a vertical pipe, submerged in the water source, and carried to the level of the irrigation ditch to be supplied. When compressed air was injected into the water, the bubbles expanded in their upward journey in inverse ratio to the pressure existing at the particular level at which they happened to be. With the expansion of the bubbles, the displaced water was pushed upward, without upsetting the static head at the base of the riser, and was eventually slopped over the top of the rising line into the ditch. With this discharge, base pressure was relieved to the extent that permitted the replenishment of the supply from the river or pond.

Once in a great while it is given us to observe the fruits of the application of brains to the solution of our problems. The case in point is that of the conservation of compressed air for sewage ejection.

The air requirements for a particular installation to lift sewage 65 ft were over 10,000 cu ft of free air, compressed to 34 lb per sq in. gage, per hr—quite an appreciable power and maintenance item. A chap who was wise enough to appreciate what our old Greek friend had done, cut in a few inexpensive gadgets, as indicated in the accompanying illustration, and now the compressor has a comparatively simple time in keeping up with the demand, and current, oil and water costs are correspondingly reduced.

The normal cycle of the ejectors, assuming that they have just been discharged, and that the static head of the sewer line is bearing on the discharge check valve, starts by the vent valve opening and relieving the internal air pressure to the vent line. Sewage then flows into the ejector chamber by gravity. When the chamber has been filled, the float controlling its operation first closes the vent valve, and then opens the compressed air supply valve. As the pressure builds up, the sewage first begins to back up in the sewer line, thus closing the inlet check. As the pressure reaches the point necessary to overcome the head on the disc of the discharge check, plus that required to overcome the inertia of the column and to start it moving, the contents of the ejector chamber are forced upward through the discharge pipe.

Obviously, when the chamber has been emptied, it must be vented to relieve the air pressure so that it may be re-filled. Equally obviously, the vented air represents a waste.

This galled the operating engineer, so he arranged to discharge the first stage of the vented air to the discharge riser, thus gaining the evacuation of a large portion of the contents thereof. When the point is reached at which the gradually reducing air pressure approaches the more slowly reducing static head pressure at the base of the riser, the air is diverted from the sewage riser and permitted to escape through the vent line.

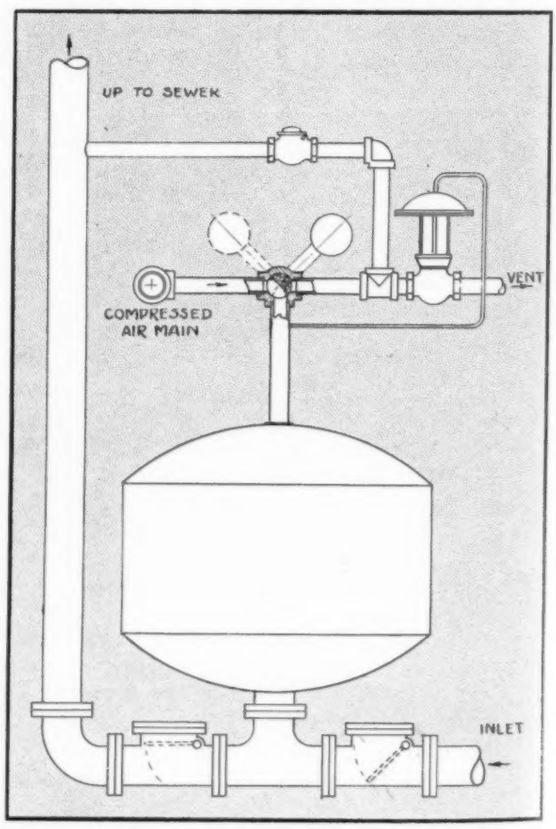
As soon as compressed air is admitted to the ejector it presses on the surface of the contents until the surface level has been depressed to its limit. The float within the chamber causes the supply to cut off, and the vent channel to be opened.

The spring loaded diaphragm valve is closed by the pressure existing within the ejector, which is communicated to the diaphragm chamber by the small air line shown. Since no other channel is available, the air passes through the swing check valve into the main sewage discharge riser.

The springs of the diaphragm valve are adjusted to open the valve when the air pressure falls to approximately 20 lb gauge. When this operation takes place, the swing check valve closes by the back pressure of air and sewage, and the remainder of the existing compression is exhausted to the atmosphere.

In the installation described, the actual savings in operating expense made through this improvement are in excess of one-fourth the original cost.

Piping arrangement that saves compressed air



How to Operate Oil Fired Heating Plants Efficiently

By **Paul R. Unger*** *and* **Kalman Steiner†**

THE material presented here is intended to serve as a general reference to the operating engineer in charge of oil fired equipment who desires to secure efficient performance of his equipment. It is also written for the engineer operating a plant equipped with the bare necessities for safe and continuous operation and interested in decreasing fuel costs further than can be done by careful supervision of operating equipment without benefit of adequate automatic combustion control. Perhaps some of the statements will seem trite and self-evident; however it seems advisable to err on the side of safety.

Cleanliness the Cardinal Virtue

Probably the cardinal virtue in any boiler room, and certainly with oil firing, is *cleanliness*. This is not intended as a remark about personal habits, but calls attention only to a technical feature concerning mechanical equipment handling fuel oil. Some believe that presence of oil at all points and places around the equipment is inevitable and merely in keeping with the nature of the stuff being handled. Happily, there are too many cases of well kept, bright and shining boiler rooms to permit this impression to become firmly established. Cleanliness in conjunction with oil burning is not only possible but is imperative to successful operation. And the things to be kept clean are not only those easily visible, but especially those that must be looked for and which are usually hidden from the casual observer.

Flues—Boiler flues are not part of the oil burning system; they must be kept clean regardless of the fuel used. Everyone likes to talk about the appalling fuel waste that occurs when boiler flues are dirty. A certain professor of engineering is frequently quoted as having stated that ⅛ in. of soot or scale has the insulating value of 2 in. of pipe covering. But it isn't necessary to quote statistics or to point with alarm. The authors are frequently asked, "How often should boiler flues be cleaned?" There is only one answer: "As often as necessary." And it should be remembered that improved technique in oil burner design is making possible the use of steadily increasing viscosities—what was called paving asphalt five years ago is today considered good fuel. This stuff has plenty of "heat" in it, and modern oil burners will get the heat out of it—but it must be expected that some soot will result. Here elbow grease or modern flue cleaning equipment must supplement the oil nozzles.

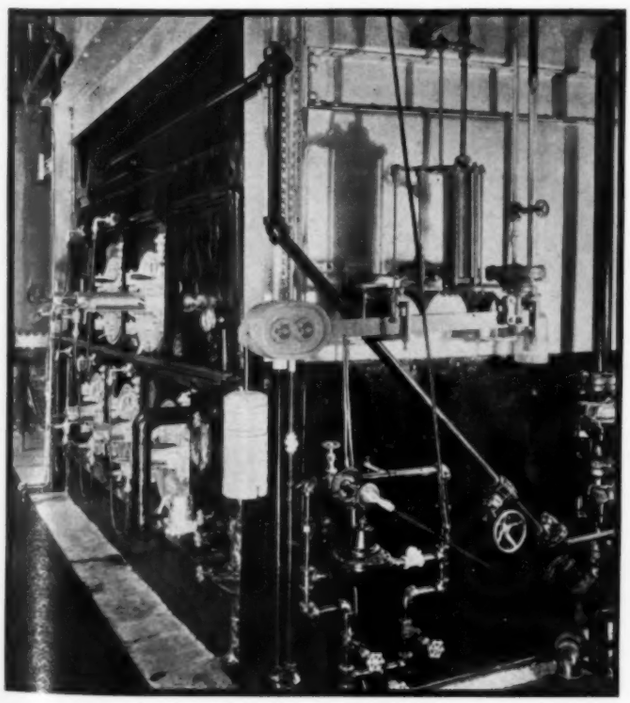


Fig. 1—Combination oil and gas fired boiler in a brewery, showing the hydraulically operated combustion control equipment and the burners. Note the cleanliness, which means efficiency

Strainers—Fouled oil strainers do not directly affect economy of operation, except that power costs for pumping will increase somewhat as the pressure drop through the strainers increases because of fouling. Duplicate oil strainers, as are usually provided in modern plants, facilitate cleaning by making possible continued operation through one set while another is being cleaned. Most operating men simply immerse the fouled strainer mesh or basket in kerosene and let it soak for a while. Others will send high pressure steam through it. As good a way as any is to wash the strainer mesh in gasoline, allowing most of the sediment to loosen and fall into the bucket; afterwards the surplus gasoline that clings to the mesh can be whisked off.

Burner Nozzles and Tips—Fouled burner nozzles and tips are another story. Sometimes their presence is immediately manifested by smoky fires or diminished steam pressure, but such visible indications of dirty oil nozzles occur usually only when the condition is aggravated. Anybody can then proceed to the cleaning job. It is far better practice to make inspections or cleanings sufficiently often, at regular intervals, so as to avoid the extremes of nozzles so badly fouled as to smoke up the

*Mid-West Heat Service Co., Chicago, Ill.
†Ace Engineering Co., Chicago, Ill.
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fires and cause pressure to drop. Usually extra nozzle tips and atomizers are inexpensive, so that a few spares can be kept on hand. It is then very simple to place a fresh nozzle on the burners and clean the one so replaced when convenient.

Fans and Blower Wheels—Fans and blower wheels will not proclaim their fouled condition as readily as will nozzles. Here it is a case of gradually accumulating sediment deposits, along with grease and grime, laid down in such fashion as to slowly but surely reduce the flow of air. The consequences are of course poorer atomization and lowered combustion efficiency. Since these devices are wholly enclosed in casings of some sort, only an inspection which involves opening the casing will reveal the true story. Experience will, in any given plant, indicate how often such inspections should be made and how often it is likely that cleaning of the fan wheels will be needed. Probably this operation is one of the most neglected matters in the routine of plant maintenance. It does not take much accumulation of dirt in a fan to knock combustion efficiency off a few points, and it does not take much time or effort to pull a blower housing apart to have a look. Here is a case where a wrench makes an excellent fuel saver.

Oil Heaters—Oil heaters can be said to have this distinction: They are the only pieces of oil burning apparatus creating their own sediment. Oil heaters are, in general, constructed like water heaters in that heat must be exchanged from one medium—steam, hot water, or an electric heating element—to another medium. But manufacturers of oil heaters usually design for a higher rate of fluid flow over the heat exchange surface; this usually means that the oil passes through a series of narrow tubes, where in the case of water heating the water would probably pass over the tubes and the steam or hot water through them. The result is that sediment formation on the heating surface has a twofold effect; it retards the flow of oil as well as the transfer of heat. In other words, as a fuel oil heater becomes dirty, it heats less oil through a smaller temperature rise. The sediment formation may in part be due to deposits brought in originally with the fuel oil, but largely it is caused by the action of heat on the oil, the heavier hydrocarbons being decomposed to form free carbon and lower weight hydrocarbons. This free carbon clings to the tube surface as a scale.

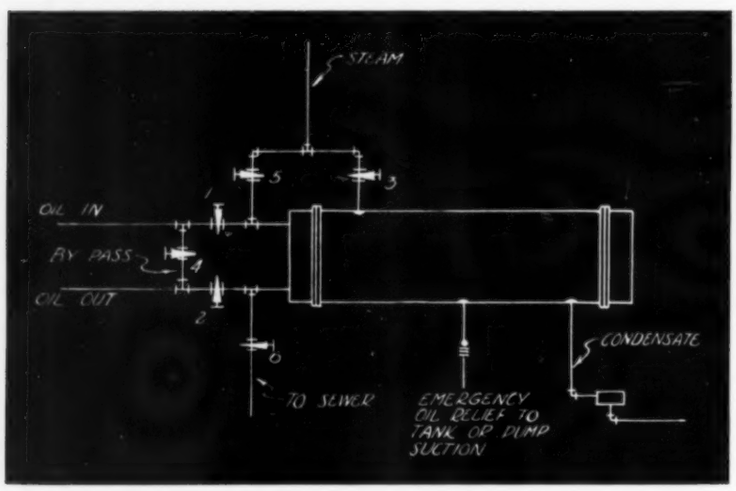

Fig. 2 — Oil preheater valved for cleaning without removing the heads. By closing valves 1, 2 and 3 and opening valves 4, 5 and 6, steam is blown through the heater to keep it clean

The reduced capacity of a fuel oil heater will not affect operation so long as the fuel is heated above the critical temperature of the oil viscosity, which is the temperature at which the oil viscosity breaks sharply to a minimum below which it does not drop appreciably on further heating. But once the oil fails to attain this temperature trouble may be expected at the burners. Of course, where electric heaters are placed after the steam heater, then any deficiency in temperature as the oil leaves the steam heater is automatically imparted by the electric heater which is cut in by its thermostat to make up the temperature deficiency. Continued use of the electric heater causes high electric energy consumption and when both steam and electric heaters are fouled badly enough, then preheating of the fuel becomes inadequate and high viscosity oil begins to reach the nozzles. This means poor atomization and loss of efficiency, which in turn mean high fuel consumption and possible difficulty in holding the load.

If straight tube heaters with external oil and steam connections are used, the heads may be removed and the tubes rodded without breaking either oil or steam connections. Fig. 2 shows a method of cleaning high pressure steam oil preheaters without removing the heads. By piping steam into the oil inlet to the heater and washing the discharge to the sewer as shown, steam can be blown through the oil passes at regular intervals and the heater thus kept clean; this is done by closing valves *1*, *2* and *3*, opening heater bypass valve *4*, and opening valves *5* and *6* blowing steam through the heater.

Storage Tank—Whether or not it saves money, the fuel oil storage tank can be and should be kept clean. Ordinarily, this is accomplished when the fuel is supplied in tank truck deliveries by having the fuel company pump out sediment deposits at periodic intervals. And the money part enters here, too—most oil companies will allow full credit for each gallon of sediment thus removed. When fuel is purchased in carload lots, then other provision must be made for cleaning out tanks. By running the tank contents low, *i. e.*, burning up as much as possible, and then opening the manhole, accumulated sediment can be removed in buckets when no special pumping equipment is available for this. Many modern plants are today provided with two suction stubs in each tank, one about 3 in. from the bottom of the tank and the other 5 or 6 in. higher. When the gradual accumulation of sediment reaches the lower suction stub, it is cut out of service. Oil to supply the burners is pulled from the high line until the sediment is removed through the lower stub or by some other method. Some plants with duplicate pumps are arranged so that sediment can be removed through the low suction stub with one pump while the other one feeds the burners.

It should now be obvious that it pays to clean up; it certainly pays equally well, if not more so, to check

up on the performance of the equipment. This check-up should have two objectives: To assure that safety devices are in proper working order, and to assure that all elements affecting combustion efficiency are under control.

Check Performance of Safety Devices

The safety devices customarily provided in an oil fired boiler plant protect against low water in boilers, failure of combustion or interruption of oil supply to nozzles, excessive boiler steam pressure, fire hazard from oil vapors in tanks or oil leaking from the pumping and piping system. Low water protection embraces low water switches (which can be wired either to interrupt oil burner operation entirely or to sound or flash an alarm bell or light), water feeding apparatus (such as float valves to control direct admission of water to boilers and float switches to control feed pump operation) and electric wiring schemes to prevent burner operation if feed water pumps are not properly energized with electric power.

Float Operated Devices—Float chambers of all float operated devices, whether switches or valves, should always be equipped with blow down connections, and periodic blow downs should be made to keep the chamber clear of sediment and scale. Immediately after the original installation the float devices should be tested by lowering the water line to see that the float mechanism is free and functioning and that the desired operation is performed by the float at the correct water level. At reasonably frequent intervals thereafter—say every six months—the float operation should again be checked to assure perfectly free motion of the float mechanism. The floats themselves are usually copper spheres subject to corrosion so that sometimes the floats become perforated and water logged. Blowing down sediment and scale will assist in preventing corrosion.

Mercury Tubes—The electrical function of a float switch is usually accomplished through the medium of a mercury tube which occasionally will develop slight cracks in the glass, allowing air to enter the tube. The arc flash which accompanies each tripping operation, if air is present, will soon oxidize the mercury and cause it to cling to the electrodes. When this condition is aggravated the tube will fail to break contact when the tube trips to the "off" position, which would keep the burner running despite low water. Only an actual test of the device will reveal this condition, so it is good practice once a month to drop the water level to check the electrical cut-out. If the electric switch is the open contact type, then testing to guard against pitted contacts is equally important.

These remarks on failure of electrical switching apply also to pressurestats installed to prevent building up of excessive steam pressure on the boilers. The easiest way to test a pressurestat is to close the king valve on the boiler for the few moments required to allow steam pressure to reach the cut-out point. (*Caution:* When doing this be sure that the boiler water is not forced out through return connections!)

Relays—It should be noted that it is not sufficient merely to test the actual tripping of the mercury tubes in low water cut-outs or pressurestats and thus to observe that the mercury runs away from the electrodes to leave a clean separation that apparently opens the circuit. These safety devices almost always operate through intermediate relays that must in turn break the main electrical circuit. At times these relays stick in a closed position and thus fail to stop the burner even though the cut-out itself has functioned properly. The writers know of at least one case where a cast iron boiler was completely destroyed by a burner continuing to run after the low water cut-out was tripped properly; the motor starting relay had jammed in the closed position and did not stop the burner at all. *Always test these safety features when the entire plant is running normally, for only in this manner does the test prove positively that the burner will stop.*

Intended to serve as a general reference to the operating engineer in charge of an oil fired plant who desires to secure efficient performance of the system under his supervision, the material presented here contains suggestions on the maintenance and inspection of the various items of equipment, checking up on the performance of safety devices, and the importance of doing so . . . . Future issues will include information on combustion and the requirements for combustion efficiency. . . . . .

With warm air furnaces, as commonly used for theater heating, the main electrical supply for the oil burners should be taken directly from the lower side of the ventilating fan switch; this assures that the burners cannot start until the fan is blowing air over the furnaces. This safeguard should be adopted even if there are also duct limit switches which operate to stop the burners when air temperatures are too high, for the time lag would be long enough to injure the furnaces before the limit devices acted.

Combustion safety switches are of two general types, manual and automatic. With the former, which is the more general in industrial work, the combustion switch must be manually closed to complete the circuit so that burners may be started. Then, should flame failure occur for any reason, the switch opens and interrupts the burner circuit. The cycle is repeated each time burner operation is desired. About the only maintenance required on this equipment is that the bi-metal helix or disc which is responsive to temperature changes must be kept clean of soot or carbon deposit so that its response to temperature changes will not be sluggish. Of course, the electrical features are subject to the same comments as already made above in connection with low water and high pressure.

As to the automatic combustion switch, while in general it serves the same functions, it must also control the ignition timing and so must be located and regulated so that it does not cut off the ignition too soon but rather delays this until the oil fire is established sufficiently to maintain itself after ignition cut-off.

(*Concluded on next page*)

Table of Properties of Pipe Aids Piping Design

THERE appeared with the article on support of industrial piping by F. L. Snyder* and T. E. Bridge†, published in the February, 1936, issue of HEATING, PIPING AND AIR CONDITIONING, a table of the properties of pipe. Because lack of space made it necessary to publish the table in a size too small for convenient use, and because many requests have been received for publication of these data in larger size, the information is again published this month. The values shown have been checked by the authors, as a few typographical errors were discovered, and the corrections have been made. Data on additional pipe sizes, including thin wall piping, have been included.

It is believed that this is the most complete table available on the physical characteristics of various pipe sizes, as it usually has been necessary to consult several different handbooks and to calculate many of the values. It has been found by the authors to be a considerable time-saver in industrial piping design work.

A similar table covering pipe sizes from 14 in. to 36 in. O.D. will appear in a later issue.

Formulas for values other than shown in the table:

$$I = 0.0491\ (D_1^4 - D_2^4) = AR^2$$

$$P = 2f\ (t/D_1)$$

$$Z = 0.0982\ (D_1^4 - D_2^4)/D_1$$

$$R = 0.25\ \sqrt[2]{D_1^2 + D_2^2}$$

$$Q = \text{Ft lb}/1000 = 2.25I/y = 4.5I/D_1$$

where

P = Ultimate bursting pressure, lb per sq in.
f = Fiber stress, lb per sq in.
A = Area of metal, sq in.
I = Moment of inertia of pipe section, inches fourth
Z = Section modulus, inches cube
R = Radius of gyration.

Q = Strength factor, representing the strength of the pipe to resist bending action. It is the resisting moment in thousands of foot pounds, the stress in the material being 27,000 lb per sq in. For other allowable stress in the material the resisting moment is directly proportional.

y = Distance of farthest fiber from neutral axis = $D_1/2$.
D_1 = External diameter of pipe, in.
D_2 = Internal diameter of pipe, in.
t = Thickness of pipe walls, in.

Pipe Wall Thickness:

Minimum thickness of pipe wall at different pressures and for temperatures not exceeding 750 F for steel or wrought iron pipe; 406 F for brass and copper pipe; and 450 F for cast iron may be determined with Formula "I" of the *A.S.M.E.* Pressure Piping Code, in which

$$t_m = (PD/2S) + C \qquad P = (2S/D)\ (t_m - C)$$

where

t_m = Minimum pipe wall thickness, in.
P = Internal pressure, lb per sq in. gauge.
(Plus water hammer allowance in case of cast iron pipe conveying liquids.)
D = Actual outside diameter of pipe, in.
S = Allowable stress in material, lb per sq in.
C = Factor for allowance for threading, mechanical strength and/or corrosion.

C VALUES

Material	*C Factor*
Cast iron pipe	0.14
Cast iron pipe pit cast	0.18
Threaded steel or wrought iron	Depth of thread
Grooved steel or wrought iron	Depth of thread
Plain end steel or wrought iron 1 in. and smaller. (Plain end includes pipe joined by flared compression couplings, laps, or van stone joints, and by welding)	0.05
Plain end steel or wrought iron sizes above 1 in. (Plain end includes pipe joined by flared compression couplings, laps, or van stone joints, and by welding)	0.065

S VALUES

Material	*Values of S*
Steel pipe seamless Grade "C" (*A.S.T.M.* A-106)	14000
Steel pipe seamless Grade "B" (*A.S.T.M.* A-106 & A-53)	11500
Steel pipe seamless Grade "A" (*A.S.T.M.* A-106 & A-53)	9000
Steel pipe lap-welded (*A.S.T.M.* A-53)	7000
Wrought iron pipe lap-welded (*A.S.T.M.* A-72)	5300
Wrought iron pipe butt-welded (*A.S.T.M.* A-72)	4500
Brass pipe seamless (*A.S.T.M.* B-43)	4500
Copper pipe seamless (*A.S.T.M.* B-42)	4000
Copper tubing seamless (*A.S.T.M.* B-75 & B-88)	4000
Cast iron pipe (*F.S.B.W.W.* P-421)	6000
Cast iron pipe pit cast (*A.W.W.A.*)	4000

[*Continued on next page*]

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†Engineering Department, E. I. duPont de Nemours & Co., Inc., Wilmington, Del.

How to Operate—

(*Concluded from preceding page*)

Stack Switches—With stack switches again we have the same story—keep them clean. Stack switches are intended primarily to prevent oil flooding of the boiler or pumping of oil into the firebox when combustion is not occurring. Ultimately, should flooding occur, oil would run back out of the boiler into the boiler room, and cause a fire hazard. Similarly, any oil escaping from pipes or pumps because of leaks or loose packing joints or connections will also constitute a potential fire hazard, especially if the oil temperature is near the flash point. Many localities have ordinances requiring that a fire extinguisher be kept in the boiler room; even in the absence of such legal stipulations, an extinguisher should certainly be on hand, and should be regularly inspected for operating order.

The inside of a steel oil storage tank is not ordinarily considered as a spot to look for fire hazard, for certainly oil cannot start to burn when so confined. But the vapors above the liquid in the tank are another story. All tanks are of course vented to atmosphere, and so the oil vapor above the liquid oil is mixed with air. When there are steam coils in the tank, a certain portion of a coil becomes exposed to the vapors as the liquid level falls. As the flash point of most heavy fuel oils is not much higher than 250 F, it can be seen that it does not require a very high pressure in the steam coil to attain this flash temperature. (The temperature of steam at 15 lb gauge pressure is 250 F; at 50 lb gauge the temperature is 298 F.) Hence, it is only common sense that some means be made available against emergencies arising from this situation. Steam smothering lines are the most logical system, as nothing will extinguish an oil fire more quickly or effectively than will live steam.

[The authors' next article explains in unusual manner the process of combustion, the requirements for combustion efficiency and how they may be attained.—THE EDITOR.]

Table of Properties of Pipe—continued

Properties of Pipe
Commercial Pipe Sizes, ⅛ in. to 12 in.

Nom. Pipe Size	Outside Diam.	Inside Diam.	Wall Thickness	Wt. per foot	Wt. of Water per Ft. Pipe	Sq.Ft. Outside Surface per ft.	Sq.Ft. Inside Surface per ft.	Transverse Area Sq.In.	Area Metal Sq.In.	Moment of Inertia	Section Modulus I/y	Radius Gyration Squared	Radius Gyration	ULTIMATE BURSTING PRESSURE* Butt-Weld	Lap-Weld	Hammer Weld	Seamless & Line Weld	Strength Factor Q 1000 ft.lb.
1/8	.405	.269	.068	.244	.0246	.106	.0705	.0568	.072	.00106	.0053	.0148	.1215	13400	-	-	22060	.01182
"	"	.215	.095	.314	.0157	"	.0563	.0364	.0925	.00122	.006	.01314	.1146	18800	-	-	28100	.01351
1/4	.540	.364	.088	.424	.0451	.141	.0955	.1041	.125	.00331	.0123	.02651	.1626	13000	-	-	19500	.0276
"	"	.302	.119	.535	.031	"	.0794	.07163	.1574	.00378	.01395	.02393	.1547	17600	-	-	26500	.03138
3/8	.675	.493	.091	.567	.0827	.177	.1295	.191	.167	.0073	.0216	.04367	.209	10800	-	-	16150	.0486
"	"	.423	.126	.738	.0609	"	.1106	.1405	.2173	.00862	.o2554	.034	.1991	14900	-	-	22400	.05746
1/2	.840	.622	.109	.850	.1316	.220	.1637	.304	.2503	.0171	.0407	.0683	.2613	10400	-	-	15550	.09156
"	"	.546	.147	1.087	.1013	"	.1433	.234	.3200	.0201	.0478	.06273	.2505	14000	-	-	21000	.1076
"	"	.252	.294	1.714	.0216	"	.066	.04987	.5043	.02424	.05772	.04807	.2192	28000	-	-	42000	.1299
3/4	1.050	.824	.113	1.130	.2301	.275	.2168	.533	.3326	.03704	.07055	.1113	.3337	8610	-	-	12900	.1587
"	"	.742	.154	1.473	.1875	"	.1948	.433	.4335	.04479	.08531	.1033	.3214	11700	-	-	17600	.1919
"	"	.675	.1875	1.727	.1545	"	.1759	.357	.5081	.0495	.0943	.0974	.3121	14300	-	-	21400	.213
"	"	.434	.308	2.440	.0633	"	.1137	.1479	.718	.05792	.1103	.08068	.2840	23500	-	-	35300	.2482
1	1.315	1.049	.133	1.678	.374	.344	.274	.864	.4939	.08734	.1328	.1769	.4205	8100	-	-	12150	.2989
"	"	.957	.179	2.171	.3112	"	.252	.719	.6388	.1056	.1606	.1653	.4066	10900	-	-	16300	.3614
"	"	.8775	.21875	2.561	.2614	"	.229	.604	.7534	.1177	.1798	.1562	.3952	13300	-	-	19900	.4028
"	"	.599	.358	3.659	.1221	"	.157	.2818	1.076	.1405	.2136	.1305	.3613	21800	-	-	32700	.4807
1-1/4	1.66	1.38	.14	2.272	.6471	.434	.362	1.495	.6685	.1947	.2346	.2913	.5397	6750	8400	-	10100	.5278
"	"	1.278	.191	2.996	.5553	"	.3356	1.283	.8815	.2418	.2913	.2743	.5237	9200	11500	-	13800	.6555
"	"	1.16	.25	3.764	.4575	"	.3029	1.057	1.107	.2833	.3421	.2565	.5063	12000	15100	-	18100	.7696
"	"	.896	.382	5.214	.2732	"	.2331	.6305	1.534	.3411	.411	.2224	.4716	18000	23000	-	27600	.9247
1-1/2	1.900	1.61	.145	2.717	.882	.497	.4213	2.036	.7995	.3099	.3262	.3876	.6226	6100	7600	-	9160	.734
"	"	1.5	.2	3.631	.7648	"	.3927	1.767	1.068	.3912	.4118	.3663	.6052	8400	10500	-	12650	.9265
"	"	1.3375	.28125	4.862	.6082	"	.3519	1.405	1.43	.4826	.508	.3375	.5809	11800	14800	-	17800	1.143
"	"	1.1	.4	6.408	.4117	"	.2903	.9503	1.885	.5678	.5977	.3013	.5489	16800	21000	-	25300	1.345
2	2.375	2.067	.154	3.652	1.452	.622	.5401	3.355	1.075	.6657	.5606	.6196	.7871	5200	6500	-	7800	1.261
"	"	2.041	.167	3.938	1.42	"	.536	3.28	1.158	.71	.5979	.6129	.7829	5600	7000	-	8450	1.345
"	"	2	.1875	4.38	1.363	"	.5237	3.142	1.289	.7764	.6538	.6025	.7764	6300	7900	-	9800	1.471
"	"	1.939	.218	5.022	1.279	"	.5074	2.953	1.477	.8679	.7309	.5875	.7665	7340	9200	-	11000	1.644
"	"	1.875	.25	5.673	1.196	"	.492	2.761	1.669	.9555	.8046	.5725	.7565	8400	10500	-	12650	1.81
"	"	1.75	.3125	6.883	1.041	"	.4581	2.405	2.025	1.102	.928	.5442	.7376	10500	13160	-	15800	2.088
"	"	1.503	.436	9.029	.7686	"	.3929	1.774	2.656	1.311	1.104	.4937	.7027	14700	18400	-	22000	2.485
2-1/2	2.875	2.469	.203	5.793	2.072	.753	.6462	4.788	1.704	1.53	1.064	.8976	.9474	5650	7100	-	8500	2.394
"	"	2.441	.217	6.16	2.026	"	.6381	4.68	1.812	1.611	1.121	.889	.943	6000	7550	-	9050	2.521
"	"	2.323	.276	7.661	1.834	"	.6095	4.238	2.254	1.924	1.339	.8539	.9241	7700	9600	-	11500	3.012
"	"	2.125	.375	10.01	1.535	"	.5564	3.547	2.945	2.3527	1.638	.7993	.8938	10400	13000	-	15700	3.685
"	"	1.771	.552	13.69	1.067	"	.4627	2.464	4.028	2.871	1.997	.7126	.8442	15400	19200	-	23000	4.493

*Note: Butt-weld -- f = 40000 lb. per sq. in.
Lap-weld --- f = 50000 lb. per sq. in.
Hammer-weld--f = 45000 lb. per sq. in.
Seamless & Line-weld --
f = 60000 lb. per sq. in.

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Table of Properties of Pipe—continued

Nom. Pipe Size	Outside Diam.	Inside Diam.	Wall Thickness	Wt. per foot	Wt. of Water per Ft. Pipe	Sq.Ft. Outside Surface per ft.	Sq.Ft. Inside Surface per ft.	Transverse Area Sq.In.	Area Metal Sq.In.	Moment of Inertia	Section Modulus I/y	Radius Gyration Squared	Radius Gyration	ULTIMATE BURSTING PRESSURE* Butt-Weld	Lap-Weld	Hammer Weld	Seamless & Line Weld	Strength Factor Q 1000 ft.lb.
3	3.5	3.25	.125	4.52	3.6	.916	.851	8.30	1.329	1.90	1.086	1.430	1.195	-	-	-	4290	2.44
"	"	3.204	.148	5.30	3.52	"	.840	8.10	1.560	2.23	1.275	1.412	1.188	-	-	-	5070	2.87
"	"	3.124	.1875	6.65	3.34	"	.819	7.70	1.958	2.70	1.545	1.380	1.175	-	-	-	6450	3.48
"	"	3.068	.216	7.575	3.2	.916	.8017	7.393	2.228	3.017	1.724	1.354	1.164	4900	6200	-	7400	3.879
"	"	3.018	.241	8.388	3.097	"	.7895	7.155	2.467	3.294	1.882	1.335	1.155	5500	6900	-	8300	4.235
"	"	2.992	.254	8.80	3.06	"	.785	7.05	2.59	3.45	1.975	1.330	1.151	-	-	-	8710	4.45
"	"	2.92	.289	9.91	2.91	"	.765	6.70	2.92	3.79	2.17	1.303	1.145	-	-	-	9900	4.89
"	"	2.9	.3	10.25	2.859	"	.7609	6.605	3.016	3.892	2.225	1.291	1.136	6900	8600	-	10300	5.007
"	"	2.875	.3125	10.64	2.81	"	.7527	6.492	3.122	4.015	2.294	1.286	1.132	7100	8900	-	10700	5.162
"	"	2.6875	.4063	13.42	2.456	"	.7037	5.673	3.948	4.808	2.747	1.218	1.103	9300	11600	-	13900	6.182
"	"	2.3	.6	18.58	1.8	"	.6013	4.155	5.466	5.993	3.424	1.096	1.047	13700	17140	-	20600	7.705
3-1/2	4.00	3.744	.128	5.38	4.78	1.047	.981	11.01	1.58	2.97	1.485	1.88	1.37	-	-	-	3840	3.34
"	"	3.732	.134	5.58	4.75	"	.978	10.95	1.64	3.07	1.535	1.87	1.367	-	-	-	4020	3.45
"	"	3.704	.148	6.26	4.66	"	.971	10.75	1.84	3.42	1.710	1.86	1.364	-	-	-	4440	3.85
"	"	3.624	.1875	7.71	4.48	"	.950	10.32	2.27	4.13	2.065	1.821	1.35	-	-	-	5640	4.65
"	"	3.548	.226	9.109	4.279	"	.9286	9.886	2.68	4.788	2.394	1.787	1.337	4500	5650	-	6800	5.386
"	"	3.4375	.2813	11.17	4.017	"	.9001	9.28	3.286	5.715	2.858	1.739	1.319	5600	7030	-	8450	6.425
"	"	3.364	.318	12.51	3.847	"	.8796	8.888	3.678	6.28	3.14	1.707	1.307	6400	7950	-	9550	7.065
"	"	3.3125	.34375	13.42	3.73	"	.8671	8.6175	3.948	6.658	3.329	1.686	1.283	6900	8600	-	10300	7.49
"	"	3.0625	.46875	17.68	3.188	"	.8017	7.3663	5.2	8.25	4.125	1.586	1.259	9400	11700	-	14100	9.261
"	"	2.728	.636	22.85	2.532	"	.716	5.845	6.721	9.848	4.924	1.465	1.21	12700	15900	-	19100	11.08
4	4.50	4.244	.128	5.99	6.14	1.178	1.111	14.15	1.76	4.21	1.871	2.390	1.545	-	-	-	3415	4.21
"	"	4.232	.134	6.26	6.11	"	1.110	14.10	1.84	4.39	1.95	2.385	1.542	-	-	-	3575	4.39
"	"	4.216	.142	6.61	6.06	"	1.105	13.98	1.93	4.58	2.035	2.375	1.540	-	-	-	3800	4.58
"	"	4.170	.165	7.64	5.92	"	1.093	13.67	2.24	5.26	2.34	2.35	1.531	-	-	-	4400	5.27
"	"	4.124	.1875	8.56	5.80	"	1.082	13.39	2.52	5.86	2.60	2.325	1.525	-	-	-	5015	5.86
"	"	4.090	.205	9.39	5.71	"	1.071	13.15	2.76	6.38	2.84	2.311	1.520	-	-	-	5470	6.39
"	"	4.026	.237	10.79	5.61	"	1.055	12.73	3.174	7.233	3.214	2.279	1.51	-	5300	-	6300	7.233
"	"	4.00	.25	11.35	5.45	"	1.049	12.57	3.34	7.56	3.36	2.265	1.505	-	-	-	6670	7.56
"	"	3.958	.271	12.24	5.35	"	1.038	12.31	3.60	8.09	3.60	2.245	1.498	-	-	-	7230	8.10
"	"	3.9375	.2813	12.67	5.269	"	1.031	12.174	3.728	8.332	3.703	2.235	1.495	-	6250	-	7500	8.332
"	"	3.826	.337	14.98	4.976	"	1.002	11.497	4.407	9.61	4.271	2.181	1.477	-	7500	-	9000	9.61
"	"	3.9	.300	13.42	5.19	"	1.023	11.96	3.95	8.75	3.89	2.216	1.487	-	-	-	8000	8.75
"	"	3.874	.3125	14.00	5.12	"	1.013	11.80	4.11	9.05	4.02	2.202	1.482	-	-	-	8350	9.05
"	"	3.75	.375	16.52	4.779	"	.9818	11.042	4.859	10.43	4.636	2.147	1.464	-	8300	-	10000	10.43
"	"	3.5	.500	21.36	4.164	"	.9164	9.6211	6.283	12.77	5.676	2.032	1.425	-	11100	-	13300	12.77
"	"	3.152	.674	27.54	3.38	"	.8262	7.803	8.101	15.28	6.793	1.887	1.374	-	15000	-	17950	15.28
4-1/2	5.00	4.506	.247	12.54	6.91	1.309	1.182	15.95	3.688	10.44	4.177	2.832	1.683	-	4900	-	5930	9.4
"	"	4.29	.355	17.61	6.262	"	1.125	14.45	5.18	14.05	5.621	2.712	1.647	-	7100	-	8500	12.65
"	"	3.58	.71	32.53	4.361	"	.9368	10.07	9.569	22.62	9.047	2.364	1.537	-	14200	-	17000	20.35
5	5.563	5.047	.258	14.62	8.659	1.456	1.321	20.01	4.3	15.16	5.451	3.526	1.878	-	4600	-	5550	12.26
"	"	4.859	.352	19.59	8.06	"	1.272	18.6	5.763	19.65	7.064	3.41	1.847	-	6300	-	7600	15.89
"	"	4.813	.375	20.78	7.875	"	1.26	18.194	6.112	20.67	7.431	3.382	1.839	-	6700	-	8100	16.72
"	"	4.688	.4375	23.95	7.472	"	1.227	17.262	7.045	23.31	8.37	3.309	1.819	-	7900	-	9330	18.85
"	"	4.313	.625	32.96	6.324	"	1.129	14.61	9.696	30.03	10.8	3.097	1.76	-	11200	-	13500	24.29
"	"	4.063	.75	38.55	5.62	"	1.064	12.97	11.34	35.63	12.09	2.966	1.722	-	13500	-	16200	27.21
6	6.625	6.287	.169	11.56	13.45	1.735	1.650	31.00	3.43	17.90	5.41	5.215	2.281	-	-	-	3050	12.15
"	"	6.265	.180	12.50	13.38	"	1.640	30.81	3.65	19.00	5.76	5.200	2.280	-	-	-	3250	12.90
"	"	6.249	.1875	12.93	13.31	"	1.639	30.70	3.80	19.71	5.95	5.19	2.279	-	-	-	3395	13.40
"	"	6.187	.219	15.02	13.06	"	1.620	30.10	4.41	22.66	6.84	5.14	2.268	-	-	-	3950	15.41
"	"	6.125	.250	17.02	12.80	"	1.606	29.50	5.01	25.55	7.71	5.10	2.26	-	-	-	4500	17.4
"	"	6.071	.277	18.86	12.55	"	1.591	28.95	5.545	28.0	8.46	5.05	2.25	-	-	-	5020	19.05
"	"	6.065	.280	18.97	12.51	"	1.587	28.99	5.581	28.14	8.496	5.042	2.245	-	4200	-	5075	19.12
"	"	5.875	.375	25.1	11.75	"	1.540	27.10	7.37	36.2	10.90	4.90	2.21	-	-	-	6800	24.6
"	"	5.761	.432	28.57	11.29	"	1.51	26.07	8.405	40.49	12.22	4.817	2.195	-	6500	-	7820	27.5
"	"	5.625	.500	32.79	10.85	"	1.475	24.85	9.63	45.6	13.78	4.74	2.15	-	-	-	9070	31.0
"	"	4.897	.864	53.16	8.14	"	1.28	18.83	15.64	66.33	20.02	4.242	2.06	-	13000	-	16650	48.06

Table of Properties of Pipe—continued

Nom. Pipe Size	Outside Diam.	Inside Diam.	Wall Thickness	Wt. per foot	Wt. of Water per Ft. Pipe	Sq.Ft. Outside Surface per ft.	Sq.Ft. Inside Surface per ft.	Transverse Area Sq.In.	Area Metal Sq.In.	Moment of Inertia	Section Modulus I/y	Radius Gyration Squared	Radius Gyration	ULTIMATE BURSTING PRESSURE* Butt-Weld	Lap-Weld	Hammer Weld	Seamless & Line Weld	Strength Factor Q 1000 ft.lb.
7	7.625	7.023	.301	23.54	16.78	2.00	1.841	38.74	6.926	46.52	12.20	6.716	2.592	-	3940	-	4750	27.45
"	"	6.625	.500	38.05	14.93	"	1.734	34.47	11.19	71.37	18.72	6.377	2.525	-	6560	-	7870	42.12
"	"	5.875	.875	63.08	11.74	"	1.538	27.11	18.56	107.5	28.18	5.791	2.406	-	11480	-	13750	63.41
8	8.625	8.309	.158	14.26	23.6	2.26	2.178	54.3	4.19	37.5	8.70	8.96	2.99	-	-	-	2200	19.6
"	"	8.295	.165	14.91	23.5	"	2.175	54.1	4.37	39.4	9.14	8.96	2.99	-	-	-	2290	20.6
"	"	8.249	.1875	16.90	23.2	"	2.161	53.5	5.00	44.5	10.30	8.90	2.98	-	-	-	2620	23.2
"	"	8.219	.203	18.30	23.1	"	2.152	53.1	5.38	47.7	11.05	8.87	2.98	-	-	-	2820	24.9
"	"	8.187	.219	19.64	22.9	"	2.148	52.70	5.80	51.3	11.90	8.84	2.97	-	-	-	3042	26.8
"	"	8.149	.238	21.43	22.7	"	2.136	52.20	6.30	55.5	12.87	8.80	2.97	-	-	-	3310	29.0
"	"	8.071	.277	24.7	22.16	"	2.115	51.16	7.265	63.35	14.69	8.721	2.953	-	3200	-	3850	33.05
"	"	7.981	.322	28.55	21.65	"	2.09	50.03	8.4	72.49	16.81	8.63	2.94	-	3700	-	4475	37.82
"	"	7.9375	.34375	30.4	21.42	"	2.078	49.48	8.943	76.80	17.81	8.587	2.93	-	4000	-	4770	40.07
"	"	7.921	.352	31.00	21.4	"	2.078	49.30	9.12	78.2	18.10	8.57	2.93	-	-	-	4900	40.7
"	"	7.875	.375	33.10	21.1	"	2.062	48.70	9.74	83.1	19.27	8.53	2.92	-	-	-	5210	43.4
"	"	7.6875	.46875	40.83	20.09	"	2.013	46.42	12.01	100.4	23.28	8.36	2.888	-	5440	-	6520	52.38
"	"	7.625	.500	43.39	19.77	"	2.006	45.66	12.76	105.7	24.51	8.283	2.878	-	5800	-	6950	55.16
"	"	7.375	.625	53.4	18.49	"	1.931	42.72	15.71	126.5	29.33	8.052	2.837	-	7240	-	8700	66.00
"	"	6.875	.875	72.42	16.07	"	1.800	37.12	21.30	162.0	37.56	7.604	2.757	-	10150	-	12200	84.51
9	9.625	8.941	.342	33.91	27.2	2.52	2.34	62.79	9.974	107.6	22.35	10.79	3.284	-	3560	-	4260	50.3
"	"	8.625	.500	48.73	25.31	"	2.258	58.43	14.33	149.6	31.09	10.44	3.231	-	5200	-	7780	69.96
"	"	7.625	1.00	92.12	19.78	"	2.01	45.66	27.1	255.4	53.06	9.424	3.07	-	10390	-	12450	119.4
10	10.75	10.37	.1875	21.12	36.7	2.814	2.72	84.5	6.20	86.5	16.1	13.95	3.74	-	-	-	2100	36.3
"	"	10.34	.203	22.86	36.5	"	2.71	84.0	6.71	93.3	17.35	13.9	3.73	-	-	-	2260	39.1
"	"	10.31	.21875	24.6	36.2	"	2.70	83.4	7.24	100.5	18.70	13.87	3.72	-	-	-	2440	42.1
"	"	10.25	.25	28.03	35.9	"	2.685	82.6	8.26	113.6	21.12	13.75	3.71	-	-	-	2790	47.5
"	"	10.192	.279	31.2	35.34	"	2.667	81.59	9.178	125.9	23.42	13.71	3.703	-	2600	-	3110	52.69
"	"	10.136	.307	34.24	34.96	"	2.655	80.69	10.07	137.4	25.57	13.64	3.694	-	2850	-	3420	57.52
"	"	10.054	.348	38.66	34.4	"	2.64	79.3	11.40	154.4	28.8	13.54	3.68	-	-	-	3880	65.0
"	"	10.02	.365	40.48	34.13	"	2.622	78.86	11.91	160.7	29.9	13.5	3.674	-	3400	-	4070	67.28
"	"	9.96	.395	43.68	33.72	"	2.61	77.91	12.86	172.5	32.09	13.42	3.664	-	3680	-	4420	72.2
"	"	9.75	.500	54.74	32.32	"	2.553	74.66	16.1	212.0	39.43	13.16	3.628	-	4650	-	5580	88.72
"	"	9.6875	.53125	57.98	31.91	"	2.536	73.71	17.06	223.6	41.6	13.11	3.618	-	4950	-	5950	93.6
"	"	9.25	.75	80.1	29.09	"	2.422	67.2	23.56	296.2	55.1	12.57	3.545	-	6980	-	8380	124.0
"	"	8.75	1.00	104.2	26.05	"	2.291	60.13	30.63	367.8	68.43	12.01	3.465	-	9300	-	11200	154.0
"	"	8.625	1.0625	109.9	25.29	"	2.258	58.43	32.34	384.3	71.5	11.88	3.446	-	9900	-	11900	160.9
11	11.75	11.00	.375	45.56	41.17	3.076	2.88	95.03	13.4	217.0	36.93	16.19	4.024	-	3190	-	3830	83.1
"	"	10.75	.500	60.08	39.32	"	2.814	90.76	17.67	280.1	47.68	15.85	3.981	-	4260	-	5100	107.3
"	"	9.75	1.00	114.8	32.34	"	2.553	74.66	33.77	492.1	83.76	14.57	3.817	-	8510	-	10200	188.5
12	12.75	12.344	.203	27.20	52.0	3.34	3.235	119.9	7.99	157.2	24.7	19.67	4.43	-	-	-	1910	55.6
"	"	12.312	.219	29.28	51.7	"	3.225	119.1	8.52	167.6	26.3	19.65	4.43	-	-	-	2060	59.2
"	"	12.274	.238	31.80	51.5	"	3.220	118.5	9.36	183.5	28.8	19.60	4.43	-	-	-	2240	65.0
"	"	12.25	.250	33.38	51.3	"	3.125	118.0	9.84	192.3	30.2	19.54	4.42	-	-	-	2350	68.0
"	"	12.192	.279	37.20	50.7	"	3.193	116.9	10.93	212.5	33.3	19.45	4.41	-	-	-	2620	75.0
"	"	12.188	.281	37.45	50.7	"	3.19	116.9	11.00	214.0	33.6	19.45	4.41	-	-	-	2640	75.7
"	"	12.15	.300	40.00	50.5	"	3.182	116.1	11.75	228.0	35.8	19.40	4.40	-	-	-	2820	80.6
"	"	12.09	.330	43.77	49.73	"	3.166	114.8	12.88	248.5	38.97	19.3	4.393	-	2590	-	3110	87.69
"	"	12.062	.344	45.55	49.7	"	3.162	114.5	13.46	259.0	40.7	19.25	4.39	-	-	-	3240	91.6
"	"	12.00	.375	49.56	48.95	"	3.142	113.1	14.58	279.3	43.82	19.16	4.377	-	2940	-	3530	98.59
"	"	11.874	.438	57.53	48.2	"	3.110	111.0	16.95	321.0	50.4	18.95	4.35	-	-	-	4120	113.5
"	"	11.75	.500	65.42	46.94	"	3.076	108.43	19.24	361.5	56.71	18.79	4.335	-	3900	-	4700	127.6
"	"	11.5	.625	80.94	44.95	"	3.011	103.84	23.81	438.7	68.81	18.43	4.293	-	4900	-	5850	154.8
"	"	11.0	.875	110.9	41.13	"	2.88	95.03	32.64	578.5	90.75	17.72	4.210	-	6900	-	8230	204.2
"	"	10.75	1.00	125.5	39.32	"	2.814	90.76	36.91	641.7	100.7	17.38	4.169	-	7840	-	9400	226.5
"	"	10.313	1.2188	150.1	36.3	"	2.7	83.8	44.15	742.4	116.5	16.82	4.10	-	9560	-	11500	262.0

*Note: Butt-weld -- f = 40000 lb. per sq. in.
Lap-weld --- f = 50000 lb. per sq. in.
Hammer-weld--f = 45000 lb. per sq. in.
Seamless & Line-weld --
f = 60000 lb. per sq. in.

New Uses for the Psychrometric Chart in Simplifying Air Conditioning Problems

By **William Goodman***

Part 4 — Reheating of the chilled air supply to conditioned rooms having low heat ratios and the run-around cycle used for reheating are the subjects this month, concluding this series on solving air conditioning problems with the "psych" chart

REHEATING of the chilled air supply for the unusual conditioned room having a low heat ratio (that is, where the latent heat gain is a considerable portion of the total heat gain) was discussed last month[1] and it was stated that two excellent methods of adding sensible heat to the chilled air supply are: (1) Warm water leaving the condensers may be circulated through a coil in the path of the chilled air leaving the cooling coils. (2) The so-called "run-around" cycle.

The first method is obvious and requires no further explanation as to its application. The disadvantage of it is that the capacity of the refrigerating plant must be increased by exactly the amount of sensible heat added to the air during the reheating process. Sensible heat from any source, when added to an air supply, always increases the required capacity of the refrigerating plant. However, in some cases, the increase is such a small percentage of the total refrigerating capacity that the method of reheating with warm condenser water may be preferred to the run-around cycle.

The Run-Around Cycle

With the run-around cycle, Fig. 12, water is circulated continuously through the precooling and reheating coils. Sensible heat, withdrawn from the warm air on its way to the cooling coils, is carried by the circulating water back to the reheating coils. These reheating coils then return the sensible heat to the chilled air leaving the cooling coils. It is apparent that the amount of sensible heat added by the reheating coils to the air is equal to that removed by the precooling coils. As a result, there is no increase in the required refrigerating capacity when using this cycle to reheat the air supply.

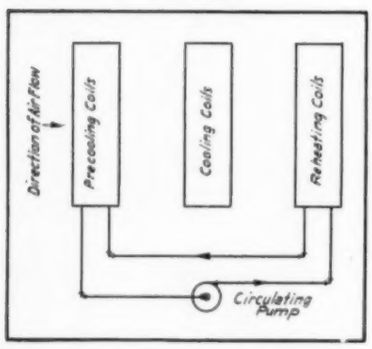


Fig. 12—Run-around cycle for reheating chilled air supply. Sensible heat is withdrawn from the air to the cooling coils and carried by the continuously circulating water to the reheating coils, where it returns to the air

When reheating with warm condenser water, it is obvious that the quantity of sensible heat added to the air supply must be as small as possible in order to keep the additional refrigerating capacity required to a minimum. When using the run-around cycle, the quantity of sensible heat added during reheating should also be kept as small as possible, as the more heat removed by the precooling coils and added by the reheating coils, the greater will be the required surface area of these coils and the larger the quantity of water it will be necessary to circulate.

Amount of Sensible Heat for Reheating

A superficial examination of Figure 10 (See April issue) may lead to the conclusion that the quantity of sensible heat needed for reheating cannot be varied because the temperature rise from *C* to *E* is fixed. Nothing, however, is further from the truth. A wide range of choice is available in deciding how much sensible heat should be added to the air supply. The answer to the whole problem lies, of course, in the selection of the point *C*, representing the condition of the air leaving the cooling coils. To how low a temperature, therefore, should the air leaving the conditioning equipment be cooled before it is sent to the reheating coils, in order that the quantity of sensible heat needed for reheating shall be the lowest possible amount?

On Fig. 13 several horizontal reheating lines have been drawn between the 90 per cent relative humidity curve and the heat ratio line *A-B*. The various points representing the final condition of the air leaving the cooling coils are numbered to distinguish them, and the relative humidity of the air leaving the various sized cooling coils required to produce the different final temperatures has been assumed at 90 per cent in each case. In the table accompanying Fig. 13 the respective quantities read from the chart for the various reheating lines are given, as are the calculated quantities of sensible heat required for reheating the air supply after it has been cooled to the various temperatures listed in the first column of the table. The quantities of supply air required have been calculated on the assumption that the sensible heat gain of the conditioned room is 2,000 Btu per minute.

*The Trane Co., LaCrosse, Wis. Copyright, 1936, by William Goodman.

[1] HEATING, PIPING AND AIR CONDITIONING, April, 1936, pp. 197-199. Also see March issue, pp. 147-150, and February issue, pp. 87-90 and p. 92.

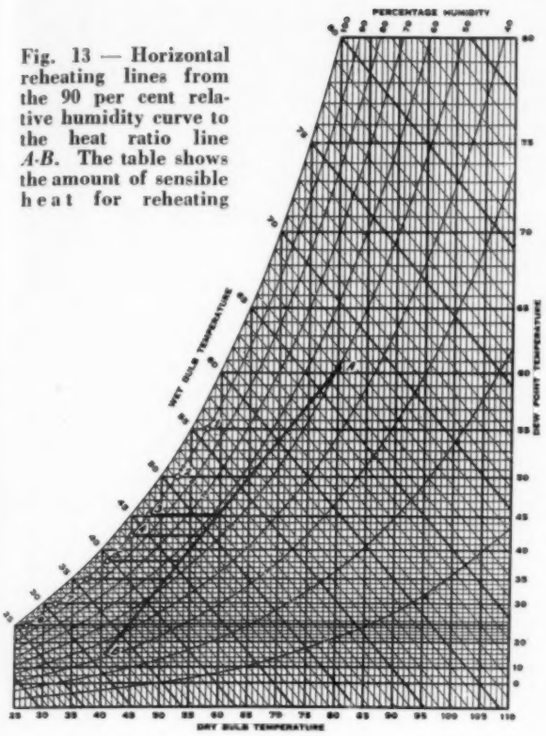


Fig. 13 — Horizontal reheating lines from the 90 per cent relative humidity curve to the heat ratio line *A-B*. The table shows the amount of sensible heat for reheating

Reheating Line No. (See Fig. 13)	Final Dry Bulb Temp., F, of Air Leaving Coils	Dry Bulb Temp., F, of Air Supply After Reheating	Rise in Dry Bulb Temp., F, of Air Supply in Conditioned Room	Lb of Air Supply Required per Min.	Rise in Dry Bulb Temp., F, of Air Supply During Reheating	Sensible Heat Required for Reheating, Btu per Min.
1	57.5	71.5	8.5	980	14.0	3290
2	52.5	65.0	15.0	556	12.5	1670
3	48	60.0	20.0	417	12.0	1200
4	45	57	23.0	362	12.0	1044
5	41.0	53.5	26.5	315	12.5	945
6	37.5	51.0	29.0	287	13.5	930
7	32	47.5	32.5	256	15.5	952
8	27	45	35.0	238	18.0	1028

The sensible heat required for reheating has been plotted, in Fig. 14, against the final dry bulb temperature of the chilled air leaving the cooling coils. The minimum point of curve *A*, occurring when the final temperature of the air leaving the cooling coils is 37.5 F, is very apparent. A change in the final air temperature in either direction results in an increase in the quantity of sensible heat required for reheating.

Upon first inspecting Fig. 13, one might be led to suspect that the minimum quantity of sensible heat would be needed when the temperature rise during reheating was lowest, that is when the horizontal line representing the reheating process was shortest. That there is no connection between the minimum temperature rise and the minimum quantity of sensible heat required is apparent from curve *B* of Fig. 14. The minimum temperature rise during reheating is 12 F and occurs when the final temperatures of the air leaving the cooling coils is 46.5 F, whereas the minimum quantity of sensible heat is required when the final temperature of the air leaving the cooling coils is 37.5 F.

Temperature of Air Leaving Cooling Coils

What, then, is the criterion for establishing, without laborious cut-and-try methods, the final temperature at

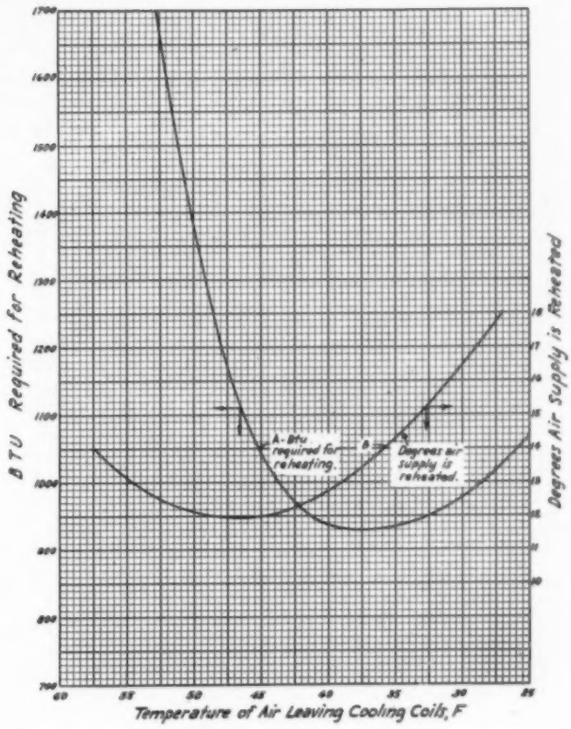

B T U Required for Reheating
Degrees Air Supply is Reheated
A-Btu required for reheating.
B-Degrees air supply is reheated.
Temperature of Air Leaving Cooling Coils, F

Fig. 14—Sensible heat required for reheating for various dry bulb temperatures of air leaving cooling coils

which the chilled air supply should leave the cooling coils in order that the sensible heat required for reheating shall be a minimum? It can be shown mathematically that the method described below gives this temperature.

Referring to Fig. 15, spot point *A* representing the room condition of 80 F dry bulb and 50 per cent relative humidity. Assume the air leaving the cooling coils has a relative humidity of 90 per cent. From point *A* draw a line tangent to the curve of 90 per cent relative humidity. The vertical dry bulb line running through the point of tangency *B* is the final temperature to which the air should be cooled. In this instance the point of tangency occurs at 37.5 F, which checks with the value obtained from Fig. 14. From Fig. 15, one can see that it is difficult to locate the exact point of tangency because the humidity curve is so flat. There is a mathematical method which yields the exact point of tangency; however, it can be located closely enough on the psychrometric chart for all engineering work and from Fig. 14 it is apparent that small errors in locating the point of tangency will have very little effect upon the final result. In Fig. 14 the sensible heat required increases only from 930 to 950 Btu when the final temperature leaving the cooling coils increases from 37.5 to 41.5 F, a range of 4 F.

The point of tangency is constant for any one room condition, but of course varies as different room conditions are assumed. Frequently such a low final air temperature is required in order to keep the sensible heat added for reheating to a minimum that the required back pressure on the refrigerating compressor would be too low. In this event, it is necessary to balance the following two factors against each other in determining the

back pressure of the compressor and the final temperature of the air leaving the cooling coils:

1. The increased horsepower due to the additional refrigerating capacity required to offset the larger quantity of sensible heat needed because the final temperature of the air leaving the cooling coils is not low enough.
2. The additional horsepower required because the back pressure on the compressor has been dropped low enough to provide the low final temperature of the air leaving the coils as required by the point of tangency.

Often it will be found that if the air is cooled to within, roughly, 5 F of the point of tangency, satisfactory results will be obtained. The sensible heat required under such conditions may be very little more than that needed when the air is cooled to the actual point of tangency. From Fig. 14, the sensible heat required for reheating from 43.5 F is but 7½ per cent greater than the quantity needed when the air is reheated from 37.5 F.

EXAMPLE 8—A conditioned room is to be maintained at 75 F and 50 per cent relative humidity. The sensible heat gain of the conditioned room is 18,000 Btu per hr and the latent heat gain is 18,000 Btu per hr. The air leaving the conditioning equipment has a relative humidity of 80 per cent. Find the cfm and condition of the air supply required in order that the sensible heat for reheating shall be a minimum. Find the temperature at which the air should leave the cooling coils and the quantity of heat required for reheating.

Solution—

$$\text{Sensible heat ratio} = \frac{18{,}000}{36{,}000} = 0.50$$

Heat ratio angle[2] = 51° 20′

Spot point *A* on Fig. 16 at 75 F and 50 per cent relative humidity. Draw heat ratio line *A-B*. Draw line *A-C* tangent to the curve of 80 per cent relative humidity. The point of tangency is at *D*.

[2]See Table 1, p. 148, March issue.

The final temperature of the air leaving the coils, as read at *D*, should be 38.5 F. The air supply will therefore be reheated from point *D* to point *E*, point *E* representing the condition of the air supply as it is introduced into the conditioned room. The condition of the air supply, as read at point *E*, should be 52 F dry bulb and 43.2 wet bulb.

The quantity of air required can be found from Equation 5.

$$Q = \frac{H_s}{1.1\ (t_r - t_s)} \qquad \text{[Equation 5]}$$

where

Q = Cfm of air to be supplied

H_s = Total sensible heat gain of the conditioned room, Btu per hr

t_r = Dry bulb temperature, F, to be maintained in conditioned room

t_s = Dry bulb temperature, F, of chilled air supply

$$Q = \frac{18{,}000}{1.1\ (75 - 52.0)} = 710 \text{ cfm, quantity of air required.}$$

The air supply is reheated from 38.5 F to 52 F.

Sensible heat required for reheating = 1.1 × 710 (52—38.5)
= 10,550 Btu per hr

It is also possible to find the sensible heat required for reheating by using the following simple equation:

$$H_r = H_s \frac{t_s - t_c}{t_r - t_s} \qquad \text{[Equation 6]}$$

where

H_r = Sensible heat added per hour in reheating the air supply.

t_c = Final temperature of air leaving the conditioning equipment.

For instance, taking the results of Example 8:

$$H_r = 18{,}000 \frac{52 - 38.5}{75 - 52} = 18{,}000 \times 0.587 = 10{,}550 \text{ Btu per hr}$$

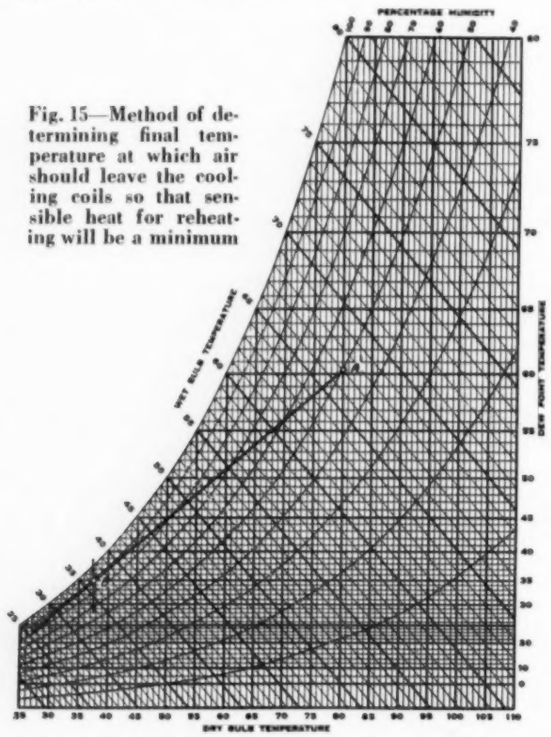


Fig. 15—Method of determining final temperature at which air should leave the cooling coils so that sensible heat for reheating will be a minimum

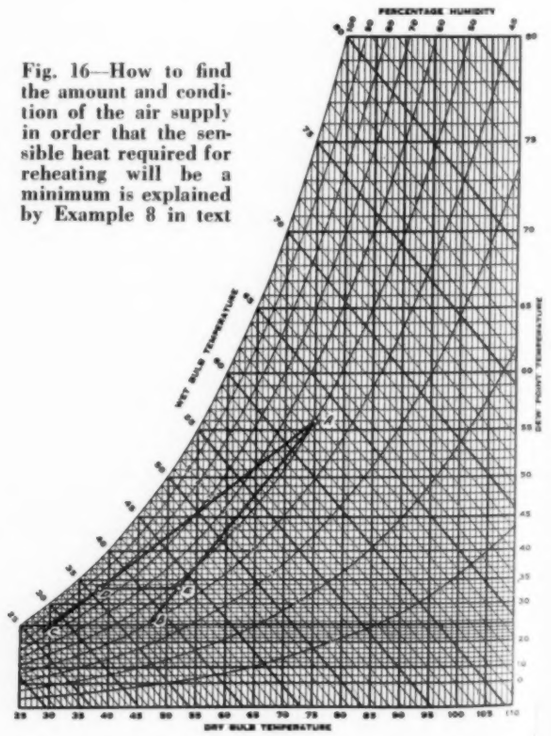


Fig. 16—How to find the amount and condition of the air supply in order that the sensible heat required for reheating will be a minimum is explained by Example 8 in text

Valve Design and Construction for High Pressure Piping

ONE of the latest high pressure steam plants is the Port Washington Station of The Milwaukee Electric Railway and Light Co., which was placed in operation last November. It should be of interest to users of valves to give a description of the operation and construction of some of the principal high pressure and special valves in this plant, as well as some details of the construction of the fittings and piping.

The plant is unique in that it is a large station built on the unit plan. There is one 80,000 kw tandem compound turbo-generator, and one 690,000 lb per hr boiler. The turbine is designed for 1230 lb gauge, 825 F temperature, and the boiler for 1390 lb. The boiler is fired by pulverized coal, with twenty vertical burners.

The steam, after passing through the high pressure section of the turbine, is extracted and piped to a radiant superheater in the rear wall of the furnace, where it is reheated to 830 F. The steam is then returned to the turbine. The maximum pressure in the reheating cycle at full load is 425 lb gauge.

Location of Valves

There are as few main operating valves as possible, but a sufficient number for quick and satisfactory service are provided. One 12 in. motor operated gate valve, designed for 1350 lb, 850 F, is placed in the main 12 in. line between the boiler and turbine. This valve can be controlled from an instrument board in the turbine room, or manually. There are two 600 lb, 18 in. motor operated gate valves, one placed in each line between the turbine and the reheater.

Two 22½ in. special intercepting valves of double seat construction are located close to the turbine, one in each of the lines between the reheater and turbine. These valves are equipped with oil operating cylinders, with spring loaded pistons on top of the stems, which will keep the valves closed when not in operation. During operation the valve is held open by turbine governor oil admitted under the piston. The intercepting valve in the line to the reheater has unbalanced discs, so that it will open when an excessive pressure is built up inside of the turbine. The intercepting valve in the reheater outlet line is provided with a handwheel operated from the turbine floor to control the pressure of steam passed to the lower stages of the turbine when starting or stopping.

These 12, 18 and 22½ in. valves, together with the turbine throttle, are the main valves between the boiler and turbine. A non-return valve on the boiler was omitted since, with a unit design, it is unnecessary. Provisions, however, were made in the piping design for installation of this and other valves when the station is extended.

For desuperheating, a 3 in. motor operated venturi valve is placed in a branch line connected into the main steam line ahead of the 12 in. shut-off valve. This valve discharges into the reheater inlet header. When starting, the operator opens the desuperheating valve and circulates steam from the main header to the inlet of the reheater to prevent temperature of the steam rising above safe limits.

Steam from the outlet of the reheater is passed through another motor operated 6 in. desuperheating valve to the station exhaust header. After the determined boiler pressure is reached, the main 12 in. gate valve is opened to admit steam to the throttle, also the two 18 in. valves in the reheater lines. A 2 in. needle valve near the turbine throttle allows steam to be passed through all of these lines for warming up. Both desuperheating valves are throttled and closed when the turbine goes into operation.

Should the turbine cut itself out automatically, steam pressure will be trapped in the reheater, and the desuperheating valves must be opened and regulated to maintain safe reheater temperatures. To protect the reheater and reheater piping, seven 3 in. safety valves set at from 490 lb to 580 lb are installed on that line.

The desuperheating valves have cast steel bodies and forged stainless steel stems, discs and seats. The desuperheating is done by water injected into the steam through nozzles at the seat ring of valves, the quantity of water being regulated through a control valve actuated by a lever attached to the stem of the main valve. The amount of water injected is, therefore, proportioned to the amount of steam passing through the valve to obtain proper desuperheating. Both valves are motor

The PortWashington Station of The Milwaukee Electric Railway and Light Co., one of the latest high pressure steam plants to go into operation, is built on the unit plan, has a turbine designed for 1230 lb pressure, 825 F temperature, and a boiler for 1390 lb. How the requirements of high pressure and temperature were met in the design and construction of the valves, piping, flanges and bolting materials was described at the power piping session of the Midwest Power Engineering Conference by H. H. MacMillen*

*Power Plant, Construction Division, The Milwaukee Electric Railway and Light Co., Milwaukee, Wis.
Presented at Midwest Power Engineering Conference, Chicago, Ill., April, 1936.

driven and are controlled by push buttons in front of the boiler board. Water for desuperheating may also be controlled manually.

Eight extraction heaters connected to five extraction points on the turbine are used for heating boiler feed water. Six of these heaters are connected to the three higher points, being arranged in pairs, and one each to the lower points. The condenser condensate pump discharges through the two lower stage heaters and into the suction piping of the boiler feed pumps. A condensate surge tank system is connected at this point. The high pressure boiler feed pumps (of which there are three, two motor driven for regular service, and one steam driven for standby) take the feed water at a temperature of 210 F and pressure of 30 lb, and discharge it through the tubes of the six extraction heaters of the three higher stages into the boiler. The maximum temperature of the feed water is 425 F. The 6 in. piping from the boiler feed pumps to the boiler and the heads and tubes of the higher stage extraction heaters are designed for a hydraulic pressure of 1800 lb.

Each set of three high pressure extraction heaters is connected into one of the two discharge lines from the boiler feed pumps. There are gate valves at the pump discharges and also at the inlet and outlet of each set of extraction heaters. Two boiler feed regulating valves are placed in front of the boiler operating panel board.

There are, therefore, two independent feed water systems for the boiler, equalized at the boiler inlet. This makes it possible to continue operation to about 75 per cent of capacity in case one feed system should fail. Bypass valves around individual high pressure heaters were omitted since there are two independent feed systems.

The boiler feed control valves are toggle top, motor operated, with cone type discs for fine regulation, the cone discs being designed so that the flow of water through each valve will be practically proportionate to the movement of the valve stem and the turning of the handwheel. These feed valves are controlled by push buttons on the boiler operating instrument board. There are no automatic feed water regulators, the entire feed being controlled by the operator.

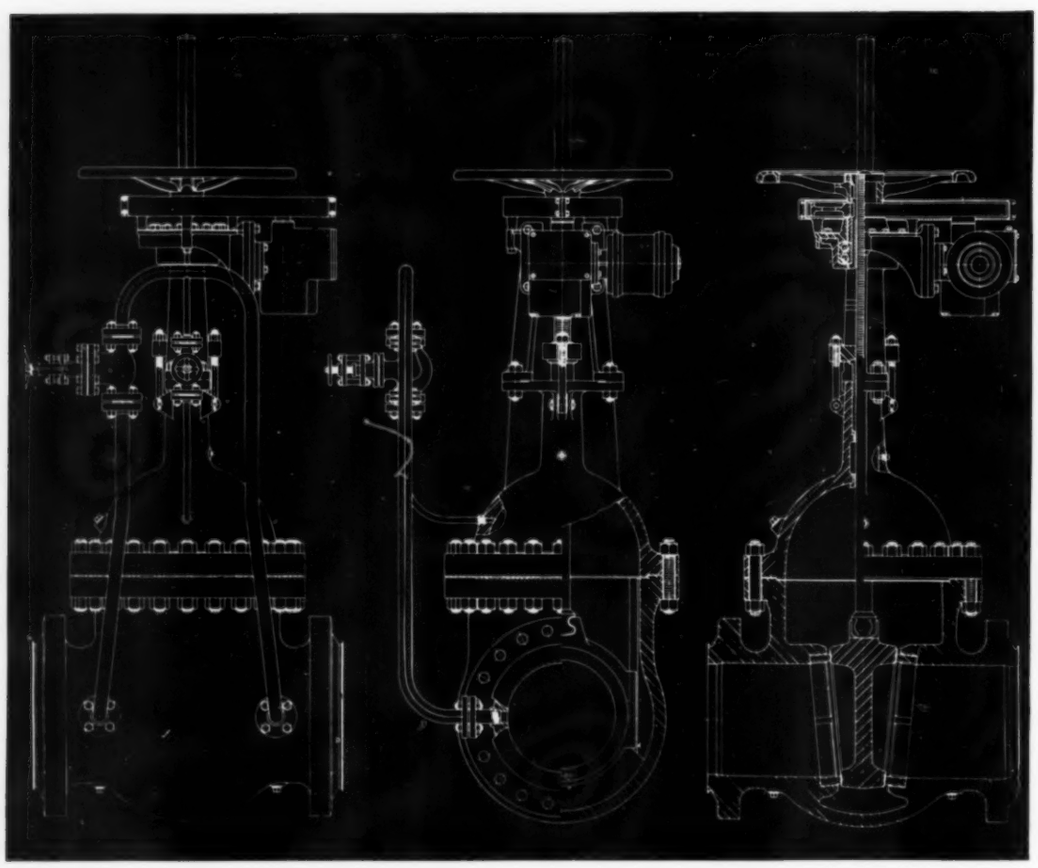
There are 6 in. stop valves and 6 in. check valves in the feed lines at the boiler.

The bleeder steam lines leading from the turbine to the extraction heaters have, in addition to motor operated gate valves, non-return, counterweighted swing check valves, which are placed as closely as possible to the turbine to prevent any back flow of steam into the turbine when shutting down.

Drain Lines, Exhaust Header, Auxiliary Piping

The high pressure steam piping is drained by bleeding through orifices and cascaded to lower pressure lines, and these lines in turn drain through traps to an exhaust header system, into which the standby auxiliary turbines exhaust. This exhaust header is arranged to spill excess steam through pressure control valves to the lower stage extraction heaters. The pressure in the exhaust line is maintained at between 2 and 3 lb gauge. A connection is made to a bleed point of the turbine to allow steam to enter the exhaust header when the pressure in the header falls below 2 lb.

The pressure regulating valves for maintaining these pressures in the exhaust header are combined spring and



18 in., 600 lb gate valve

weight loaded: they have cast steel bodies, parabolic discs, seats and stems of chrome nickel steel, radiator cooled necks, with sufficient space between diaphragms and valve bodies so that diaphragm will not become overheated.

Most of the auxiliaries for the station are motor driven. A few operating and standby units are steam driven, such as one boiler feed pump, one house service pump, steam jet air pumps, and soot blowers. The steam for these units is taken from the 1325 lb line between the radiant and convection superheater at a maximum temperature of 720 F and is reduced in pressure through orifices to the pressure required for each particular unit.

The condenser is single pass with 52,500 sq ft of surface. Condenser circulating water is supplied by two 55,000 gpm pumps which take water from a well connected directly by intake to Lake Michigan. Two 48 in. hydraulically operated gate valves are placed in the discharge lines between the circulating pumps and the condenser. By means of solenoid operated valves on the hydraulic cylinders, if the current on a motor fails, the gate valve in the pipe line will close. This prevents loss of circulating water if one motor fails, also back flow of water from the condenser in case of both motors failing on an emergency shut down, thereby making it possible to hold the prime of the pumps.

Materials of Valve Construction

The valves for a system of this kind range from a hydraulic pressure of 50 to 1800 lb, and from a steam pressure of 125 to 1390 lb, with temperatures up to 850 F. The standards of design for 1500 lb, 600, 300 and 150 lb, for fittings and piping were followed. All flanged valves and fittings for 150 lb steam pressure and above have Sarlun faces for weld sealing. The piping has Van Stone Sarlun flanges.

The previous installations at the Lakeside plant, which were made in this way, had given no piping troubles; therefore the same design was followed. The design, however, of this piping, valves and fittings, was made in 1932, and while welding neck valves, fittings and flanges were considered for the higher pressures and temperatures, it was felt at that time that our previous practice should be followed.

The total number of valves in this station are 2250, of which approximately 1400 are designed for above 300 lb steam pressure.

The materials used in the construction of all Sarlun flanged high pressure gate valves are alike. Bodies and bonnets are chrome molybdenum steel, with chemical and physical analysis as follows:

Chemical		*Physical*	
Carbon	0.15-0.35	Tensile strength	110,000 lb per sq in. min.
Manganese	0.45-0.85	Yield point	75,000 lb per sq in. min.
Silicon	0.20-0.60	Elongation in 2 in.	18 per cent
Chromium	4.0 -6.5	Reduction in area	30 per cent
Molybdenum	0.40-0.65		
Phosphorus	0.05 Max.		
Sulphur	0.05 Max.		

Gates are wedge type, of chrome molybdenum steel, with stellited faces. Seat rings are screwed in and are made of stainless iron with stellited faces. Yokes are cast steel with ball bearings. Yoke nuts are Tobin bronze, gland bonnet bushings and stuffing box bushings stainless iron. Stems are stainless iron. Bonnet bolts, yoke bolts and gland bolts are *S.A.E.* 3140.

Steam and water gate valves 5 in. and above are equipped with a bonnet equalizing pipe connected into the regular bypass on the valve. This connection is made so that the pressure on the top and bottom of the gate can be balanced, since there is a tendency for the gate to lift suddenly or jump when the gate is being moved off its seat. Although a minimum clearance is allowed between the stem and gate, our previous experience at Lakeside proved that only by balancing the gate in this manner could all shocks, vibrations or chattering of discs be eliminated when valves are being opened.

Bonnets are also equipped with bleeder valves independent of the bypass connections and used for checking tightness against leakage. Both bypass and bleeder valves are of forged steel construction, with the trim similar to main valves. Bends for bypasses are seamless tubing, with male and female flanges.

All gate valves are designed to open and close under a full flow of steam or water, which is a very severe service necessitating parts of ample strength. Stellite was used in facing the surfaces of the gates and seats to prevent galling, erosion or cutting, and to prevent leakage and lessen shut downs. The stellite, No. 6, has the following chemical composition—

Cobalt	45.0 to 60.0 per cent
Chromium	30.0 to 35.0 per cent
Tungsten	2.0 to 16.0 per cent

The tensile strength is 76,000 lb per sq in. Elongation rarely exceeds 5 per cent, and reduction in area is not detectable. The seats and discs are first machined to provide clean surfaces for the stellite and the alloy is flowed into the surfaces by means of an oxy-acetylene blow-pipe. Finally the stellited surfaces are ground to the desired finish.

Globe valves not mentioned above have the same kind of materials for their different parts as the gate valves. They are also equipped with stellited discs and seats for erosion and wearing.

Small globe valves below 2 in. for drip, drain, and blow down purposes, have forged steel bodies and bonnets, with swivel plug discs, renewable seats, and stems, all of stainless steel. Valves for 1350 lb pressure have flanged bonnets; for 450 lb pressure, screwed bonnets. Bypass valves on the large gate valves, also some needle regulating valves, have stellited contact surfaces on the stainless steel seats and discs. Instrument line valves are of the needle type with screwed ends and screwed bonnets. Check valves on the smaller lines are forged steel construction, piston type, with stainless steel trim.

The safety valves used on the boiler, superheater and reheater are of the exposed spring type, with cast steel bodies, bottom inserted seat bushings, and bushings and feathers of nitralloy. Blow-off valves on the boiler are 2 in. cast steel, angle type.

The metal in the fittings is the same as that in the valve bodies.

Piping, Flanges and Bolting

Piping—All pipe for high pressure and high temperature is seamless drawn tubing known as "Grade B" (0.30 to 0.40) carbon steel, conforming to the standards adopted by the *A. S. M. E.* Boiler Construction Code, and the State of Wisconsin Boiler Code. All piping

conforms to the latest standard of thickness and material adopted by the *A. S. T. M. Specification* 106 for high temperature service, with chemical and physical analysis as follows:

Chemical		*Physical*	
Carbon	0.30-0.40	Tensile strength	65,000 lb per sq in. min.
Manganese	0.40-0.60	Yield point	38,000 lb per sq in. min.
Phosphorus & Sulphur	0.04 Max.	Elongation in 2 in.	25 per cent
Silicon	0.25 Max.		

All piping was erected to allow for proper expansion by pulling the bends two-thirds of the required expansion between anchor points when cold, so that when heated to the actual temperature, the bends would be under a slight compression.

Flanges—Flanges used on all piping for 150 lb and above, are Van Stone Sarlun except where connections are made to equipment or where special valves might have to be taken out of the line, in which case male and female joints with phonograph finish were used. All flanges conformed to the *A. S. A.* for the different series. Cast chrome alloy steel was used on all high pressure lines, with characteristics as follows:

Chemical		*Physical*	
Carbon	0.25-0.50	Tensile strength	100,000 lb per sq in. min.
Silicon	0.20-0.45	Yield point	65,000 lb per sq in. min.
Manganese	0.45-0.75	Elongation in 2 in.	18 per cent
Chromium	0.65-0.95	Reduction in area	30 per cent
Nickel	1.75-2.25	Creep stress of 1 per cent in 100,000 hr	
Sulphur	0.06 Max.	@ 11,000 lb per sq in. and at 850 F	
Phosphorus	0.05 Max.		

Male and female joints were made with only a few thousands clearance in diameter. Actual measurements were taken or templates made of flanges for equipment or valves purchased, and forwarded to the piping manufacturer so that the corresponding face of flange could be made to suit.

Bolting—For temperatures above 750 F, chrome tungsten steel bolts were used, all bolts threaded full length. Nuts for all bolts are of the same material, oil quenched.

Chemical		*Physical*	
Carbon	0.30-0.40	Tensile strength	130,000 lb per sq in.
Manganese	0.70-0.90	Elastic limit	110,000 lb per sq in.
Phosphorus	0.04	Elongation in 2 in.	18 per cent
Sulphur	0.05	Reduction in area	55 per cent
Chrome	0.30-0.60	Tensile strength at 800 F	120,000 lb per sq in.
Tungsten	0.90-1.25		

To insure that all bolts would be stressed equally in joints for high temperature lines, their lengths were measured before and after pulling up with micrometer calipers, and they were stretched about 0.002 in. per in. free length, causing 50,000 lb per sq in. initial stress. Unless this was done certain bolts would be greatly overstressed and would give trouble due to creep. Special provision was made in the flange insulation to permit easy removal for future inspection to determine creep in the metal of the bolts.

All bolts for temperatures under 750 F are made from forged chrome nickel steel. This steel is known as *S. A. E.* 3140.

Chemical		*Physical*	
Carbon	0.30-0.40	Tensile strength	125,000 lb per sq in.
Manganese	0.50-0.80	Yield point	105,000 lb per sq in.
Phosphorus	0.04	Elongation in 2 in.	16 per cent
Sulphur	0.045	Reduction in area	50 per cent
Nickel	1.0 -1.5		
Chrome	0.45-0.75		

In conclusion, it should be stated that the design and selection of the valves and other piping materials for this station represent our own personal conclusions and interpretations of the requirements for the operating conditions peculiar to this station. The designs and selections were based on many years of operating experience in the other stations built and operated by the company. It is hoped that the years of operation that lie ahead of this station will justify the design and selection that has been made.

Air Conditioning Improves Quality of Honey —Apiaries Get 100% Return on Investment

THE Hodgson Apiaries, Jarvis, Ontario, received over a 100 per cent return the first year on their investment in air conditioning for the storage of honey through improvement of its quality; as a result, it was recently decided to double the original installation made over a year ago.

As honey has a tremendous affinity for water, the job was one of dehumidification. When first installed a temperature that was too low to be satisfactory was held, as the honey containers sweated badly and the cartons became soggy. The temperature was raised and the equipment operated by manual control, allowing the condensing unit to run for several hours collecting a heavy frost on a blower type coil, then stopping unit and defrosting quickly. In this way the relative humidity was lowered to 36 per cent. An automatic device which operates the equipment so as to obtain the desired results was then designed.

The original storage room was 18 ft wide, 15 ft deep and 12 ft high, located in the basement of building and insulated with 2 in. of cork and earth banked on three sides.

It is of interest to note that the crop of honey last year was 90,000 lb, which was disposed of immediately at top prices, 1½ cents per lb more than various competitors received, and some producers still have considerable honey on hand. Samples of honey showed a great difference in quality and texture. Sample No. 1 was honey put immediately in cold storage, the texture being very fine, similar in appearance to lard. Sample No. 2 was honey put in storage two weeks after processing and the texture was similar to fine granulated sugar. Sample No. 3 was honey not put in storage and the texture was quite coarse.

The contractor was The Culley Electric, Hamilton, Ontario.—J. W. RAMSDEN.*

*The Culley Electric, Hamilton, Ontario, Canada.

Heating·Piping
and Air Conditioning

American Society of Heating and Ventilating Engineers JOURNAL SECTION

MAY 1936

Table of Contents

Development of Testing Apparatus for Thermostats, by D. D. Wile 271
Study of Summer Cooling in the Research Residence Using Water from the City Water Mains, by A. P. Kratz, M. K. Fahnestock, S. Konzo and E. L. Broderick 278
Joint Session at Buck Hill Falls 289
Honorary Members 292
Candidates for Membership 301
Candidates Elected 302

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Development of Testing Apparatus for Thermostats

By **D. D. Wile*** ***(NON-MEMBER)***, **Detroit, Mich.**

EVERY engineer is familiar with the important part that the thermostat plays in every day life. It forms the fundamental control feature of every air conditioning system and most ordinary heating or cooling plants.

Much has been done in recent years to improve the performance of thermostats and especially is this true of wall type thermostats used to control air temperature in a home or any other type of building. As in the case of most developments, it is important to have a suitable test method or *measuring stick* to determine the progress or improvement. This paper describes a new test method which has been used to determine the accuracy of thermostats in the control of air temperatures, and to assist in the recent developments of new instruments.

For comparison the testing of an immersion type thermostat which has a remote bulb suitable for controlling the temperature of liquids may be considered. The bulb

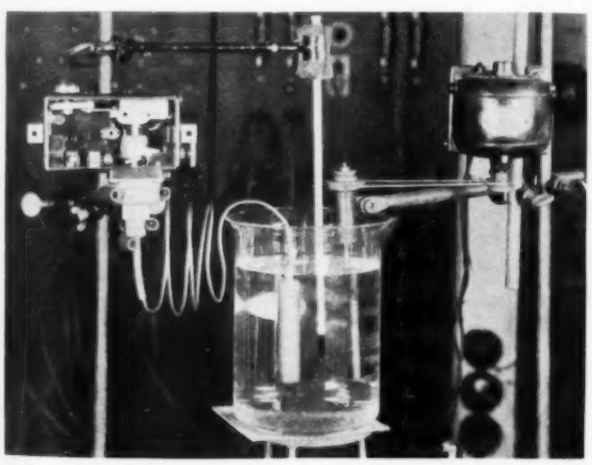

Fig. 1—Immersion type thermostat tested in liquid bath

is placed in a liquid bath (Fig. 1) having an agitator and an accurate thermometer. Then by slowly changing the temperature of the liquid, the cut in and cut out points, or the so-called differential of the instrument may be determined.

The same procedure may be applied to the thermostat for controlling air temperatures (Fig. 2), and by exercising proper care, the cut in and cut out points may be measured accurately and thus the actual differential may be determined. If this thermostat is placed on the wall of

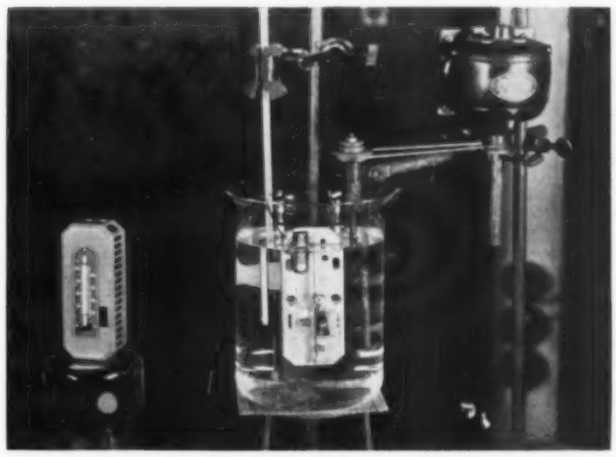

Fig. 2—Wall type thermostat tested for actual differential in liquid bath

a room a different condition is obtained. When the air is heating up, as shown in Fig. 3, the sensitive element lags behind, and the air temperature rises above the actual cut out point of the instrument. The same condition of over-shooting exists at the cut in point, with the result that the air temperature may fluctuate several degrees with a thermostat which operates in a liquid bath at a fraction of one degree.

The amount of this over-shooting of the air temperature depends upon air velocity and also on the rate of temperature change. The thermostat controls most accurately in fast moving air and slowly changing temperature.

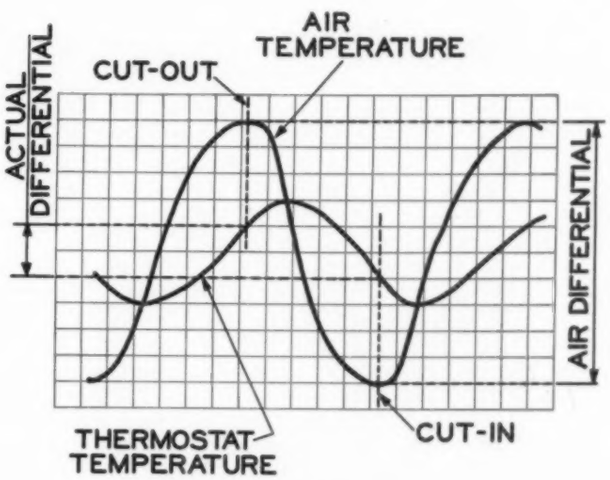

Fig. 3—Lag of air temperature

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For presentation at the Semi-Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, June, 1936, Buck Hill Falls, Pa.

In order to determine the accuracy of these instruments it is the usual practice to operate in a specially constructed test room, but the results may often be unreliable and the test conditions may not even simulate practical operation.

Description of Apparatus:

Several years ago it was decided to develop a reliable and simple method for testing the response of wall type thermostats. One of the problems was to determine the conditions which surround the average wall thermostat both in respect to air velocity and rate of temperature change and then build equipment to duplicate these conditions in the most reliable manner. The apparatus shown in Fig. 4 is the result of this development. It consists of an insulated test chamber and a control panel and forms a completely automatic test apparatus.

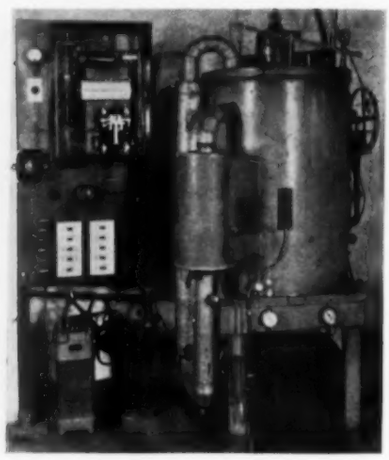

Fig. 4—New test apparatus and control panel

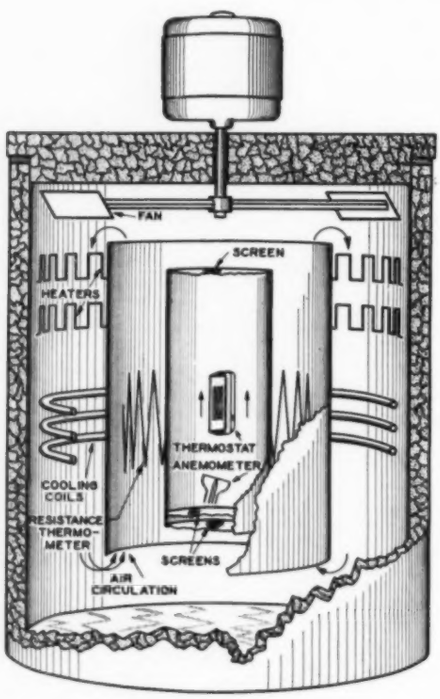

Fig. 5—Cross-section of test cabinet

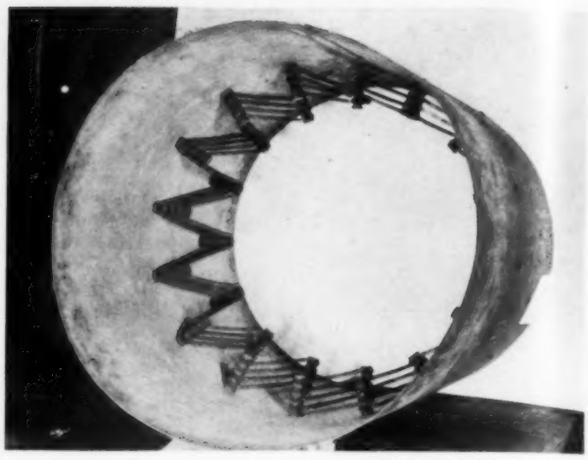

Fig. 6—View of resistance thermometer

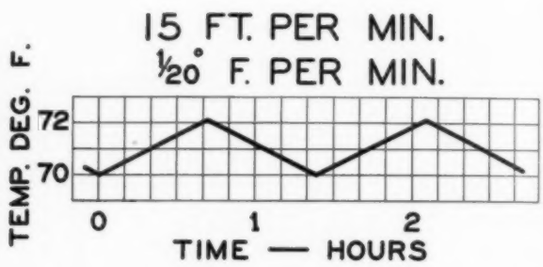

Fig. 7—Regulation of air temperature in test cabinet

Within the cylinder (Fig. 5) a special type fan forces a rapid circulation of air down the outside and up the inside of a cylindrical baffle tube. Within this tube is mounted another smaller cylinder whose ends are covered by a series of fine screens. These screens decrease the air velocity and insure a uniform velocity over the complete area of the tube.

The thermostat is mounted within this inner tube and may be subjected to a wide range of air velocities by regulating the number of screens over the ends of the tube and also by the speed of the fan. Air velocity over the thermostat is measured by an electrical anemometer, the construction of which will be described later.

Fig. 5 also shows the electric heater, the refrigerating coils for cooling and the resistance thermometer. This thermometer consists of a long length of nickel wire which changes its electrical resistance with any change in air temperature. As shown in Fig. 6, the wire is wound into a long spiral and mounted around the inside wall of the baffle tube. This construction provides a large amount of wire surface to come in contact with the air and permits the thermometer to follow the air temperature even though it change at a rapid rate. This was an important consideration since any discrepancy in the measuring instrument would reflect directly in the test results.

Before describing the control circuit, it is desirable to explain the general operation of the system. When the thermostat cuts in and out it does not turn the heat on and off in the usual manner as this arrangement was not sufficiently reliable. Instead it was decided to make the temperature increase or decrease at a definite rate,

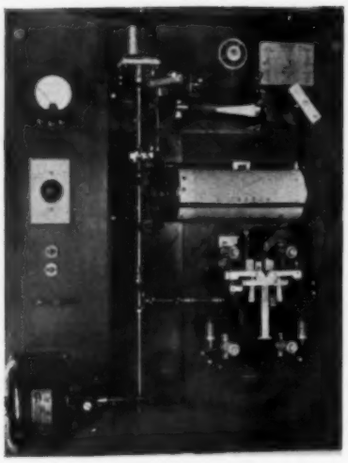

Fig. 8—View of control panel

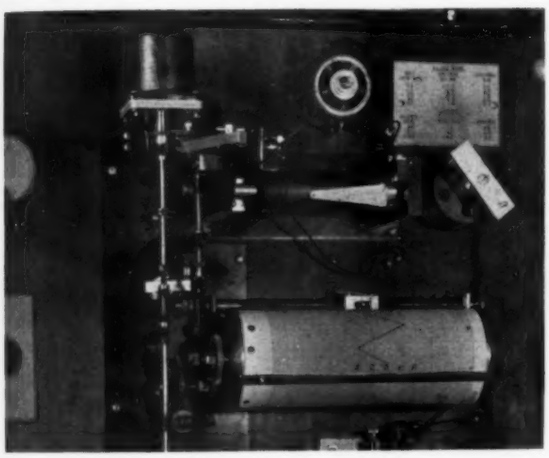

Fig. 9—Slide wire and recorder drum

as shown in Fig. 7. When the thermostat calls for heat, the temperature starts to increase at a uniform rate and continues until the cut out point is reached and then starts decreasing at the same rate.

Obviously this condition is not the same as exists in practice since no such uniformity is ever found in practical operation. However, this is a condition that can be accurately controlled and reliably reproduced at any time. It thus provides an excellent basis for comparing one type of design against another and furnishes the necessary measuring stick for developmental work. In order to prove the reliability of the apparatus, tests have been repeatedly conducted on the same thermostat at intervals of more than one year apart and, with the same test conditions, obtaining identical results. Moreover, experience has shown that by using comparable air velocities and observed rates of temperature change, the test results predict the performance of the thermostat in the field.

The performance shown in Fig. 7 is accomplished by an electrical control circuit comprising the resistance thermometer shown in Fig. 6, a sensitive galvanometer and a slide wire mechanism connected together in the form of the Wheatstone Bridge. The apparatus is mounted on a control panel as shown in Fig. 8. At the top is the slide wire and below this is a recorder drum, while at the bottom is the galvanometer. These units are driven through a system of gears by a synchronous motor shown at the lower left hand corner.

The contact on slide wire (Fig. 9) moves along at a constant rate of speed and sets the pace for the rate of temperature change in the cabinet. This unit is driven from the main vertical drive shaft through change gears, which provide any desired rate of motion, and thus any corresponding rate of temperature change. The position of the contact along the slide wire determines the temperature in the cabinet at any given time. This slide wire is very accurate, requiring a complete turn to change the cabinet temperature one degree. There are 35 turns in the slide wire with a corresponding temperature range of 35 F; therefore, a manual adjustment is provided to change the operating range when running tests at very high or very low temperatures. This adjustment is located on the right of the mechanical slide wire, and is seldom changed except when special tests are required at very low or very high temperatures.

The unit in the upper left hand corner is a solenoid which is energized when the thermostat in the test case calls for heat and is used to reverse the rotation of the upper portion of the main drive shaft. This view shows the solenoid in the de-energized position with the small bevel gear in mesh and the upper shaft driven in reverse direction. When energized, the solenoid raises the upper

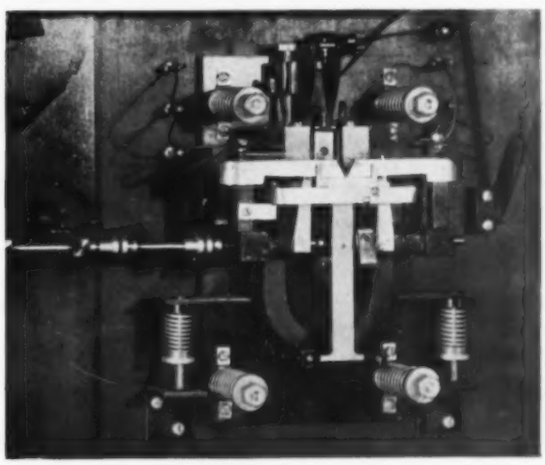

Fig. 10—Power driven galvanometer

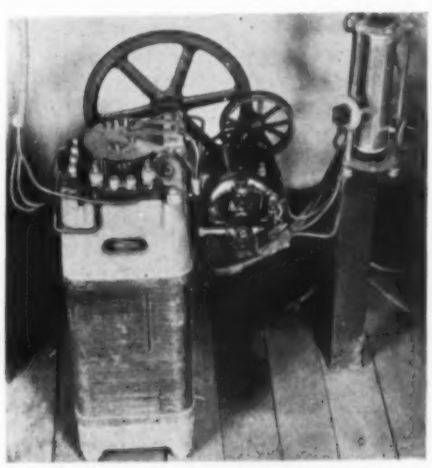

Fig. 11—Motor driven voltage regulator

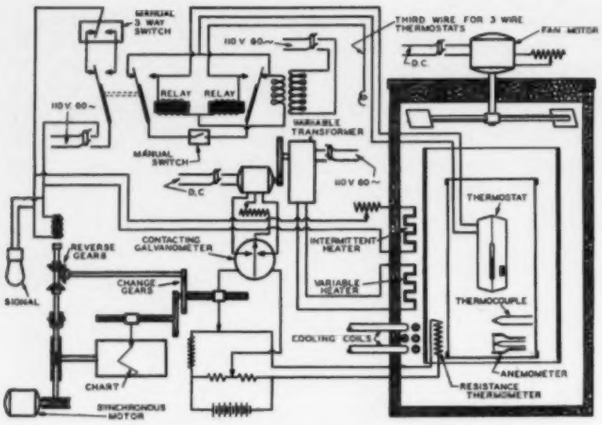

Fig. 12—Schematic wiring diagram of apparatus

Fig. 13—Anemometer used in test cabinet

part of the shaft, lifting the upper bevel gear out of mesh and allowing a positive clutch to engage, thus driving in the opposite direction than when the bevel gears are in mesh.

The recorder drum (Fig. 9) is rotated by gears driven from the main drive shaft. The recording stylus, however, is driven from a secondary shaft connected to the slide wire mechanism. The drum therefore rotates at a uniform timed speed, while the marking pen follows the motion of the slide wire contact and makes a record of the time of thermostat operation along with the actual variation of air temperature, thus obtaining a complete automatic record of thermostat performance.

The galvanometer (Fig. 10) is the nerve center of the system. It is connected in circuit with the resistance thermometer shown in Fig. 6 and may instantly respond to a change in temperature in the cabinet of less than 2/100 F and insures that the air temperature constantly follows the pace set by the slide wire. When out of balance, this delicate galvanometer starts into action a positive mechanical motion to operate a set of electrical contacts.

These contacts in turn control the operation of a small motor on the voltage regulator (Fig. 11) causing it to start, stop, or reverse, depending upon whether the temperature in the cabinet is too high or too low. This regulator, therefore, supplies current to the main heater in the cabinet at exactly the required amount to offset heat leakage through the cabinet walls and also to counterbalance the refrigeration load. The refrigerator operates continuously throughout both heating and cooling cycles and makes the apparatus independent of outside temperatures. The insulated walls permit operation at relatively low temperatures.

Fig. 12 shows a schematic wiring diagram, the complete diagram being somewhat more complicated. Relays are used so that only a small current need be carried by the thermostat contacts and the relays further provide for testing two or three wire instruments or refrigeration type instruments where the contact action is reversed. When required, any current desired may be thrown across the thermostat contacts and it may be made to operate under load conditions.

Testing Method

During test when the thermostat cuts in, the temperature must instantly change from a decreasing to an increasing rate and this involves a considerable change in the heat input to overcome the thermal capacity of the air and other parts within the cabinet. While the temperature is falling, the cabinet parts are giving up heat and while rising they must receive heat. This instantaneous demand is met by a secondary heater operated by the thermostat through a relay. The heater turns on when the thermostat calls for heat and supplies the correct amount to satisfy the sensible heat load of the cabinet parts. Once properly adjusted for a given rate of temperature change, the heater needs no further attention since any small variations are corrected by the main heater.

This arrangement may appear to be a complicated layout, but actually it works out in practice simply. After the equipment is set into operation, it continues automatically without any attention. In addition, automatic safety devices are incorporated which not only protect the equipment, but also shut it off after a predetermined length of time. Often tests are started near the end of the day and allowed to run automatically to completion. At the end of the test the equipment stops operating and is ready the next morning with a chart showing the performance of the thermostat under test.

Electrical Anemometer

The anemometer for measuring the air velocity presented a problem since it was necessary for it to give accurate results at extremely low velocities and also

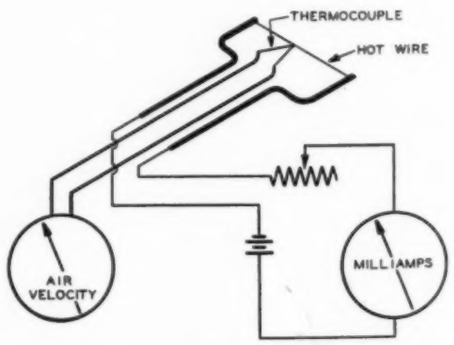

Fig. 14—Wiring diagram of anemometer shown in Fig. 13

Fig. 15—Portable anemometer

it had to be of a construction which would not interfere with the smooth flow of air near the thermostat. The hot wire type of electric anemometer was selected to meet these requirements and it was necessary to conduct an elaborate investigation in order to develop this type of instrument.

Fig. 13 shows the type of anemometer used in the test apparatus. This device is arranged in a protecting tube so that it may be withdrawn for protection against damage during the time when a thermostat is being installed in the case and then merely pushed into position when the test is started.

A schematic diagram of this anemometer is shown in Fig. 14. It consists of a small resistance wire known as the *hot wire* stretched between two supports and supplied with electric current which may be accurately measured by a milliammeter. Near the center of this hot wire is attached a thermocouple made of extremely fine wire and connected to a very sensitive potentiometer which is capable of measuring one-tenth of a millionth of a volt. The potentiometer reading indicates the temperature of the hot wire to an accuracy of 1/200 F. This hot wire, being of such a small diameter, is easily cooled even by a slow movement of air, and therefore the reading of the potentiometer may readily be calibrated to show the actual air velocity passing over the hot wire.

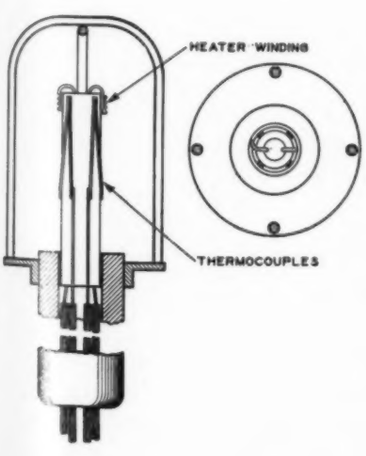

Fig. 16—Detail of measuring tip of portable anemometer

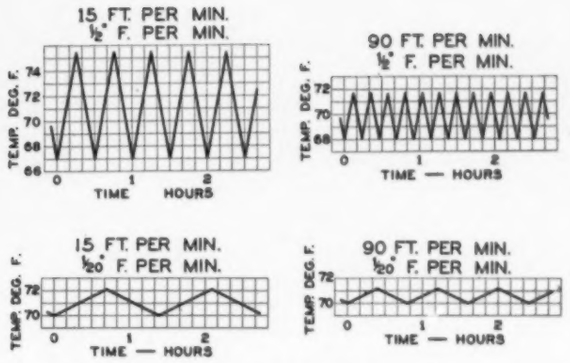

Fig. 17—Results when instrument is tested at various air velocities and rates of temperature change

Portable Anemometer

The anemometer shown in Fig. 13 was satisfactory for use in the test cabinet but it was not suitable for making measurements in the field, and it was therefore necessary to determine the actual air velocity existing in normal installations in order to establish proper test conditions. A portable anemometer was subsequently developed which could be depended upon to give sufficient accuracy in actual installations and yet permit speed and ease in taking readings. Fig. 15 shows the portable type anemometer as it was finally developed. It consists of a measuring tip connected by means of a flexible cable to a meter box calibrated in actual air velocity. The complete equipment including the batteries, switches, rheostats, etc., is arranged in the meter box.

Although the portable instrument works on a hot wire principle, the construction of the measuring tip (Fig. 16) was modified considerably in order to obtain sufficient accuracy with a portable meter. The hot wire used in this instrument is wound around a small tip and over the top of several thermocouple junctions. These thermocouple junctions being connected in series permit the production of an appreciable voltage with a small amount of heat generated by the hot wire. Some idea of the size of this tip may be realized by noting that the largest outside diameter is less than the size of a fountain pen.

By the use of this tip construction, the actual temperature of the hot wire rises only a few degrees above room temperature and therefore does not in itself disturb the air motion. This anemometer proved entirely satisfactory for measuring the comparatively slow air velocities encountered near the walls of residences and other buildings. It has also been used in various types of laboratory tests and at one time was used in a large mine to make a complete survey of air velocities existing in the various tunnels and working spaces where the velocities were too low to be measured by the usual Pitot tube.

In houses heated by radiators or gravity circulated warm air, the velocities at the walls where thermostats are usually located were found to vary from nearly 0 to 40 fpm. The average for good locations was between 15 and 30 fpm. Velocities vary with the heating load, being much more rapid during extremely cold weather when the heating plant is operating under heavy load conditions.

Application of Test Apparatus

The effect of air velocity and rate of temperature change is shown in Fig. 17 by the four tests made in the apparatus at widely varying conditions. The same thermostat was used in each of these conditions without any change of adjustment. It was carefully checked before and after the tests to insure that it had not changed. In Fig. 17 the first two or three cycles have been omitted from each of the curves, as these first cycles are usually irregular while the thermostat is settling down after which the cycles are regular regardless of how long the test is continued. It is generally possible to complete a run in 3 hours. The results of a

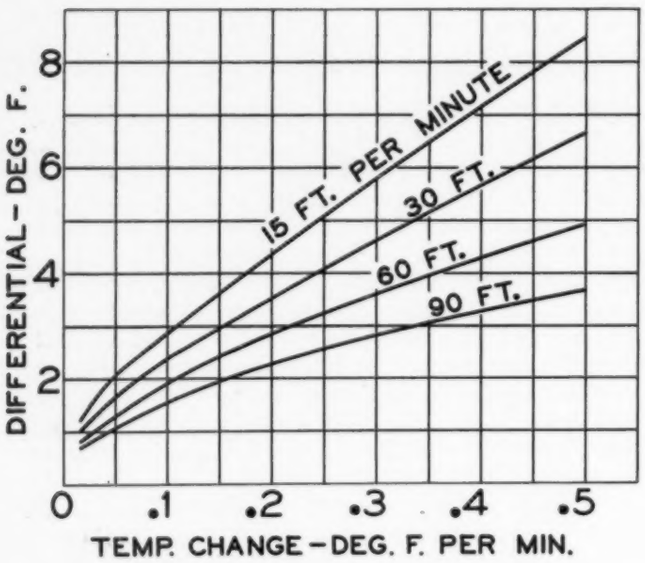

Fig. 18—Effect of various air velocities and rates of temperature change on a wall type thermostat

complete series of tests are shown in Fig. 18 and demonstrate the effect of air velocity and rate of temperature change on thermostat operation.

The test apparatus has recently been of value in a long series of tests on anticipating or heat accelerated type thermostats. A few of these test results will be shown because they demonstrate the value of proper test equipment in this type of development work.

The anticipating or heat accelerated type of thermostat has a small heater element inside of the case, which applies heat to the sensitive element or blade as soon as the instrument cuts in. The heat supplied to the sensitive element anticipates the warming up of the room air and may be adjusted so that the thermostat operates on a small differential. This action is shown in Fig. 19 where it will be noted that when operating without the heater the instrument had a differential in air of 4 deg but this reduced to ½ deg when the heater was thrown into the circuit. This type of instrument provides a positive action while maintaining close control of the air temperature. The action of the heater generally makes it unnecessary to locate the instrument in a region of high velocity and in some installations this has certain advantages since the most desirable ther-

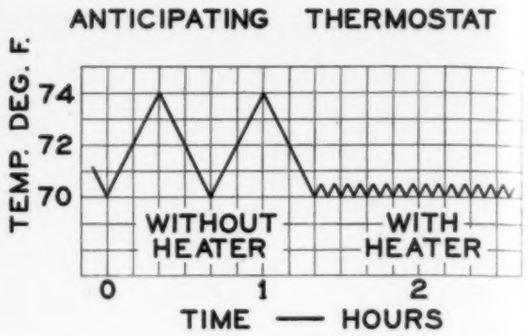

Fig. 19—Effect of anticipating heater element on thermostat operation

mostat location from a standpoint of air movement is in some cases the most undesirable location from the standpoint of appearance.

In order to satisfy various types of installations, the amount of heat imparted to the blade must be variable and there are several means of accomplishing this result. Fig. 20 shows the construction of a thermostat with the anticipating heater element on an adjustable mounting so its distance from the sensitive blade may be subjected to change. In this instrument no adjustment is provided for the voltage to the heater element and it is purposely kept constant by means of a third wire brought in from the transformer. The heater element is separated from the control circuit and therefore the anticipating effect is independent of the electrical load on the thermostat. The anticipating effect is regulated by changing the position of the heater element relative to the sensitive blade and thus provides a means of obtaining the desired operation on any type of installation.

If the heat imparted by the heater element to the blade is increased sufficiently, the thermostat will cut in and out at intervals without requiring any change in the air temperature. Under some conditions of operation this is desirable, especially where the heating plant has a long *carry-over*. The thermostat may be made to compensate entirely for the *lag* and *carry-over* in the heating plant and provide uniform temperature where such accuracy of control is desired.

The design of this instrument involved many test

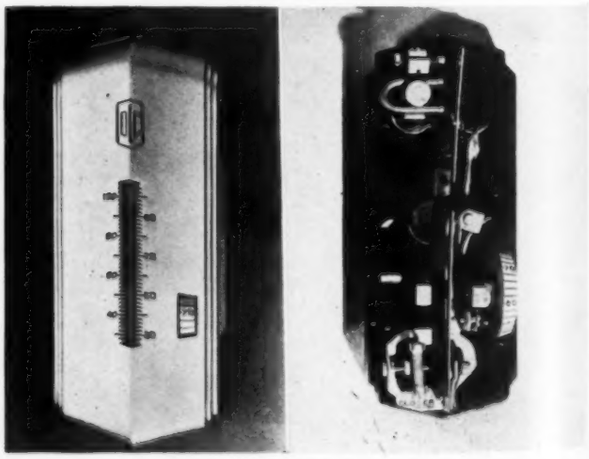

Fig. 20—View of an anticipating type thermostat

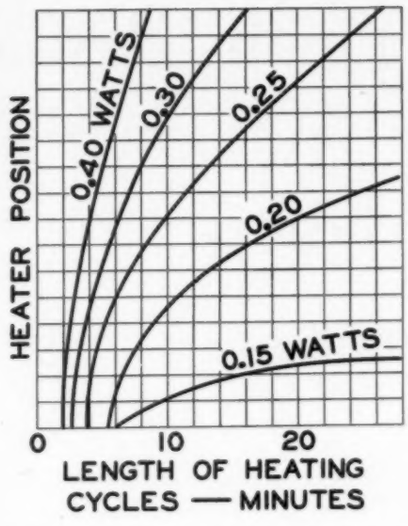

Fig. 21—Results at various heater loads and heater positions

runs in order to determine the proper amount of watts supplied to the heater element and also the effect of various positions of the element. The size of louvers or vent holes in the outside case also plays an important part. This information was easily obtained by the use of the test apparatus described in this paper. Fig. 21 shows a sample of the test results and indicates the effect on thermostat operation of both the position of the anticipating heater and the watts supplied to it.

These data were necessary in the design of the thermostat and it would have been a most difficult, if not impossible, task with the usual method of test. The special test apparatus made it possible to obtain these data in comparatively short time. This apparatus has been in almost constant laboratory use for a period of several years and has contributed an important part in the continued improvement of thermostat design. It has reduced the testing of thermostat response to an exact science and provided the necessary measuring stick.

A.S.A. Program for Measuring and Labeling Sounds

During the past 20 years we have witnessed an unparalleled development in applied acoustics, says Vern O. Knudsen, Chairman, Sectional Committee on Acoustical Measurements and Terminology of the *American Standards Association*. The phenomenal growth of radio and the revolutionary effects of adding sound to motion pictures have done much not only to accelerate this development but also to build up a sound-conscious public. Social and civic organizations became interested not only in better sound but also in less noise. It became apparent that noise reduction was beneficial not only to the preservation of good health but also to the promotion of good economy. Workers in quiet surroundings were found to do more and better work than those in noisy surroundings. The acoustical treatment of offices, restaurants, and theaters was found to be an investment which would often yield more than 10 per cent.

A basic standard for the measurement of sound is as fundamental in the control of noise as are basic foot and pound reference standards in the control of length and weight. Such a standard has just been established for the first time through the work of an *American Standards Association* committee, directed by the *Acoustical Society of America*.

Measurement of sound is the first step in the control of noise. The approval by the *American Standards Association* of the American Tentative Standards for Sound Level Meters (Z24.3-1936) and the American Tentative Standards for Noise Measurement (Z24.2-1936) eliminates the element of chance in determining how loud a sound actually is.

The standard loudness "reference level" provides a basic unit as a starting point from which all sound can be measured.

The standard for meters makes it possible to obtain the same results for the same sound when measured by any type of standard meter.

Members of the sectional committee are:

V. O. Knudsen, *Acoustical Society of America*, Chairman
J. W. McNair, *American Standards Association*, Secretary
Acoustical Society of America, Dr. Harvey Fletcher, H. A. Frederick, Prof. V. O. Knudsen, Prof. D. C. Miller.
Acoustical Materials Association, John S. Parkinson, Wallace Waterfall
American Gas Association, Dr. F. E. Vandaveer
American Institute of Electrical Engineers, P. L. Alger, C. R. Hanna, Bassett Jones, Prof. B. F. Bailey (alt.), Dr. Ellsworth D. Cook (alt.), Prof. H. M. Turner (alt.)
American Institute of Physics, Dr. Henry A. Barton
American Medical Association
American Otological Society, Inc., Dr. Edmund P. Fowler.
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Music Industries Chamber of Commerce, Paul H. Bilhuber
National Association of Fan Manufacturers, A. A. Criqui, J. L. Lennon (alt.)
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U. S. Navy Department, Bureau of Engineering, Officer in Charge, Design Division, Specification Section, Bureau of Engineering; Laboratory Officer, Material Laboratory (alt.)
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Study of Summer Cooling in the Research Residence Using Water from the City Water Mains

By A. P. Kratz,* M. K. Fahnestock,** S. Konzo,† *and* E. L. Broderick ‡ *(MEMBERS)*

Urbana, Ill.

This paper is the result of research sponsored by the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, *in cooperation with the National Warm Air Heating and Air Conditioning Association and the University of Illinois, and conducted in the Research Residence at the University of Illinois.*

PREVIOUS investigations in summer cooling in the Research Residence during the summers of 1932,[1] 1933,[2] and 1934[3] made use of either ice as the medium for cooling water circulated through coils placed in the forced-air heating system or a two-ton mechanical refrigerating unit used in connection with evaporator coils placed in the forced-air heating system. These investigations were confined largely to studies of certain factors affecting the cooling load, and to studies of the effectiveness of different methods of circulating air from the outdoors at night, both as a supplement to artificial cooling during the day and as a means for eliminating the necessity for artificial cooling during the day. The investigation for the summer of 1935 was undertaken to determine to what extent water from the city water mains, available at a temperature of from 58 to 60 F, could be used to produce satisfactory cooling and dehumidification in the Research Residence when supplemented by the circulation of outdoor air through the second story at night and when approximately one air change per hour of outdoor air was used for the purpose of ventilation during the day.

Description of the Research Residence and Cooling Equipment

The Research Residence, shown in Fig. 1, together with the forced-air heating system has been described in a previous paper.[4] For the purpose of this investigation the Residence was equipped with awnings at all east, south, and west windows, and the sun-room was isolated from the rest of the house by closing the doors

Fig. 1—View of Research Residence in Urbana, Ill.

leading into the dining room. The entire third story was regarded as an attic, and during the daytime was isolated from the rest of the house by closing the door at the head of the stairs. The attic windows, however, were opened to provide ventilation in the attic both day and night. With the exception of the space above the northwest bedroom and the small spaces adjacent to the dormer windows, the third story had hardwood floors laid on pine sub-flooring. The small spaces adjacent to the dormer windows had no floors. In the space above the northwest bedroom 1 in. of insulating blanket was nailed to the upper edges of the floor joists. Hence, approximately all second floor ceilings were at least equivalent to lath and plaster with flooring above it. Practically no cooking was done in the kitchen, but the heat transmitted through the glass doors from the sun-room, which was not ventilated by opening the windows, compensated for this to a certain extent. Unless otherwise specified, the state of the Residence was the same for the work done during the four summers.

The arrangement of the forced-air duct system and fan is shown in Fig. 2. For the purpose of this investi-

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[1] A.S.H.V.E. Research Paper, Study of Summer Cooling in the Research Residence at the University of Illinois, by A. P. Kratz and S. Konzo, A.S.H.V.E. TRANSACTIONS, Vol. 39, 1933, p. 95.

[2] A.S.H.V.E. Research Paper, Study of Summer Cooling in the Research Residence for the Summer of 1933, by A. P. Kratz and S. Konzo, A.S.H.V.E. TRANSACTIONS, Vol. 40, 1934, p. 167.

[3] A.S.H.V.E. Research Paper, Study of Summer Cooling in the Research Residence for the Summer of 1934, by A. P. Kratz, S. Konzo, M. K. Fahnestock and E. L. Broderick, A.S.H.V.E. JOURNAL SECTION, *Heating, Piping and Air Conditioning*, January, 1935, pp. 29-40.

[4] Loc. cit. Note 1.

Presented at the Joint Session of *National Warm Air Heating and Air Conditioning Association* and AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, 42nd Annual Meeting, Chicago, Ill., January, 1936.

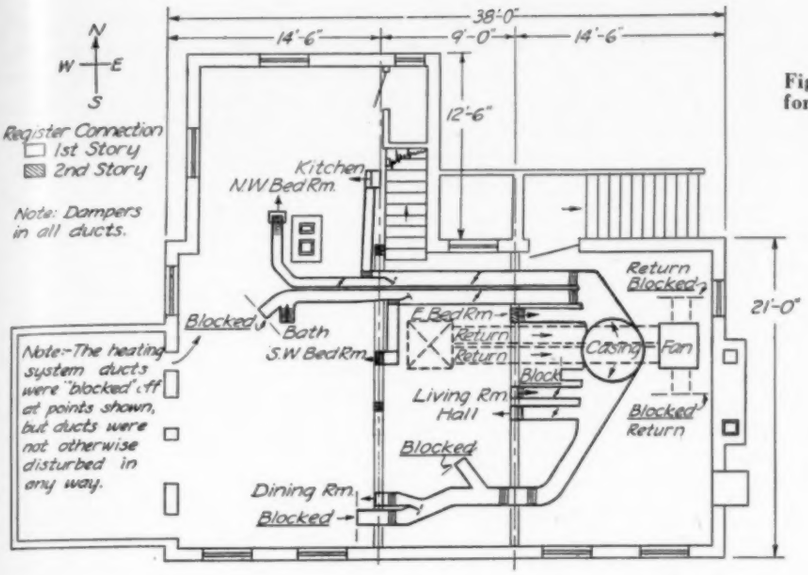


Fig. 2—Basement plan showing duct layout for forced-air system in use for distributing cool air

gation, all return ducts with the exception of the central one containing the cooling coil were blocked. The delivery ducts to the sun-room and third story were blocked, as indicated, and the dampers in the ducts to the first and second stories were adjusted to maintain the proper balance between the amounts of cooling required on these two stories.

The arrangement of the cooling plant is shown in Fig. 3. The cooling coil consisted of 8 rows of finned tubes and one row of tubes without fins. Each row consisted of 12 tubes connected into headers or return bends at the ends of the tubes. These headers were connected in such a way that the water flowed across the duct through one row of twelve tubes and returned through the next row, thus alternating through each succeeding row of tubes. The water connections were made so that the flow of the water was counter to the flow of the air, thus providing that the coldest air came in contact with the tubes containing the coldest water. The coil was arranged so that the air flowed horizontally. The water from the city service main passed through a calibrated water meter before entering the coil. As shown in Fig. 3 the tubes were grouped in sections of one, two, or three rows, and valves were provided so that different numbers of rows could be used to conform with different temperatures for the entering water. The tubes were $\frac{5}{8}$ in. outside diameter and had 8 fins per inch. The overall diameter including the fins was $1\frac{7}{16}$ in. As arranged in the duct, the gross face section of the coil was $17\frac{9}{16}$ in. high and $35\frac{1}{2}$ in. wide, giving a gross face area of 4.33 sq ft. The net face area was 3.56 sq ft. The net free area was 1.76 sq ft. The total area of cooling surface, including the row without fins was 429 sq ft, and based on a volume of air circulated of 1277 cfm the gross face velocity was 295, the net face velocity was 359 and the velocity through the net free area was 726 fpm.

The selection of the cooling coil was based on the following considerations. Previous tests with a mechanical refrigerating unit in the Research Residence (Table 1, 1934)[5] had indicated an actual maximum cooling load of approximately 30,000 Btu per hour, of which 22,000 was sensible heat and 8,000 was latent heat load. Since, in the case of cooling with water, no additional load corresponding to the heat loss from the condensing unit and motor would be imposed, it was considered that these figures could be reduced approximately 10 per cent, and a total cooling load of 27,000 Btu per hour consisting of 20,000 Btu sensible heat and 7,000 Btu latent heat was assumed as a basis for the selection of the water coils. It was further considered desirable to operate the house under the same conditions as before with a room temperature of 80 F dry-bulb and with the air leaving the registers at approximately 70 F. Since the temperature rise in the ducts between the coil and the registers had been found to be approximately 4 F, the air was required to leave the coil at a temperature of 66 F. The admission of one air change per hour from outdoors to serve as ventilating air raised the temperature of the air entering the coils to approximately 81 F. The probable temperature drop through the coil would therefore be 15 F. From this temperature drop and the 20,000 Btu per hour, the amount of air to be circulated was calculated as 5,560 lb per hour or approximately 1300 cfm. The temperature of the available service water was approximately 60 F, and a rise of 10 F in the water passing through the coil was assumed. From this rise and the total cooling load of 27,000 Btu per hour, the probable water requirement was determined as 324 gal per hour.

From the manufacturer's catalog a stock coil unit was selected such that with 1300 cu ft of air flowing per minute a net face velocity of 365 fpm would be obtained. With this unit the water velocity was estimated as 0.556 fps, and from the temperatures of the entering and leaving air and water, the logarithmic mean temperature difference was calculated as 8.26 F. Following the manufacturer's recommendation, the heat transmission was based on the sensible heat alone. The overall heat transmission coefficient of 5.60 Btu per square foot per degree mean temperature difference per hour, corresponding to a water velocity of 0.556 fps and an air velocity of 365 fpm was selected from the manufacturer's published data. The sensible cooling load of 20,000 Btu per hour required 433 sq ft of coil surface and this condition was approximately satisfied by 8 rows of tubes in the type of coil used.

The operation of the cooling plant was controlled by means of a thermostat located at the 60-in. level in the hall on the second story. This thermostat was used in connection with a motor-operated, water-valve placed on the outlet side of the cooling coil to start and stop the

[5]Loc. cit. Note 3.

flow of water through the coil. The valve was either open or closed and moved slowly enough to prevent any water hammer.

In order to provide for both heating in the winter and cooling in the summer, the cooling coil was installed in a by-pass in the central return duct as shown in Fig. 3. For the summer work, the duct was blocked with tightly fitting dampers at *B* and *C*, and all of the air delivered by the fan in the forced-air heating system passed through the cooling coil when the air in the house was being recirculated. For the purpose of providing outdoor air for cooling during the night, a slide damper, *E*, was placed in the by-pass on the down-stream side of the coil, and a door, *G*, was placed in the recirculating duct on the down-stream side of the slide damper. For a few of the earlier tests this door was located as shown at *F* in Fig. 3, but its use was discontinued owing to difficulties in measuring the air delivery from the fan. When outdoor air was required, the basement door and the door, *G*, in the recirculating duct were opened, and the slide damper, *E*, was closed. The fan in the forced-air system was driven by a V-belt from a ¾ hp motor and delivered approximately 1,300 cu ft of air per minute when recirculating the air in the house and 2300 cfm when using outdoor air at night. Outdoor air, for the purpose of ventilation during the day, was provided by means of the duct shown as Detail *A* in Fig. 3. This duct contained a venturi section for the measurement of the volume of air delivered, and it was necessary to use a small auxiliary fan in order to deliver the equivalent of approximately one air change per hour. Wet-and dry-bulb temperatures of the air entering and leaving the cooling coil were measured by means of thermometers. Two pairs of these thermometers were placed on each side of the coil, a pair near each side of the duct. The bulbs were located about 5 in. from the sides of the duct, and at about the middle of the height of the cross section. As a check on these thermometers, two hair hygrometers were also located in the duct in cross-sections corresponding to the locations of the thermometers. The temperature of the water at inlet, at outlet and at intermediate points was measured by means of thermometers as shown in Fig. 3. The locations of thermometers and thermocouples for measuring the temperature of air at other points and the location of Pitot tubes for measuring the air quantities are also shown in this figure.

Method of Conducting Tests

During the summer continuous records were made, by means of temperature recorders, of the following air temperatures: outdoor, living room, dining room, kitchen, first, second and third story halls, east bedroom, southwest bedroom, and northwest bedroom. Continuous records were also made of the temperatures of the air entering and leaving the cooling coil, the water entering and leaving the cooling coil, the outdoor air taken in for ventilation and the wet-and dry-bulb temperature of the outdoor air on the north side of the house. Other incidental air temperatures were read at regular intervals. Relative humidities both indoors and outdoors were observed by means of an aspirating psychrometer. The outdoor wet- and dry-bulb readings on this psychrometer served as a basis for correcting all outdoor wet-and dry-bulb temperatures read from the recorder charts.

During the periods of operation, observations were made of the weight of water circulated through the cooling coil, the temperature of the water entering and leaving the coil, the weight of water condensed from the air and the electrical input to the fan motor. The weight of water circulated was obtained by means of a calibrated water meter and the air quantities were obtained from traverses made with Pitot tubes at section *D* in the central return duct and at the venturi section in the ventilating air duct as shown in Fig. 3.

During all of the tests the windows on the first story remained closed. The windows in the attic, with the exception of one opposite the door at the top of the stairs, remained open. For the purpose of cooling with outdoor air at night, 11 windows on the second story were opened

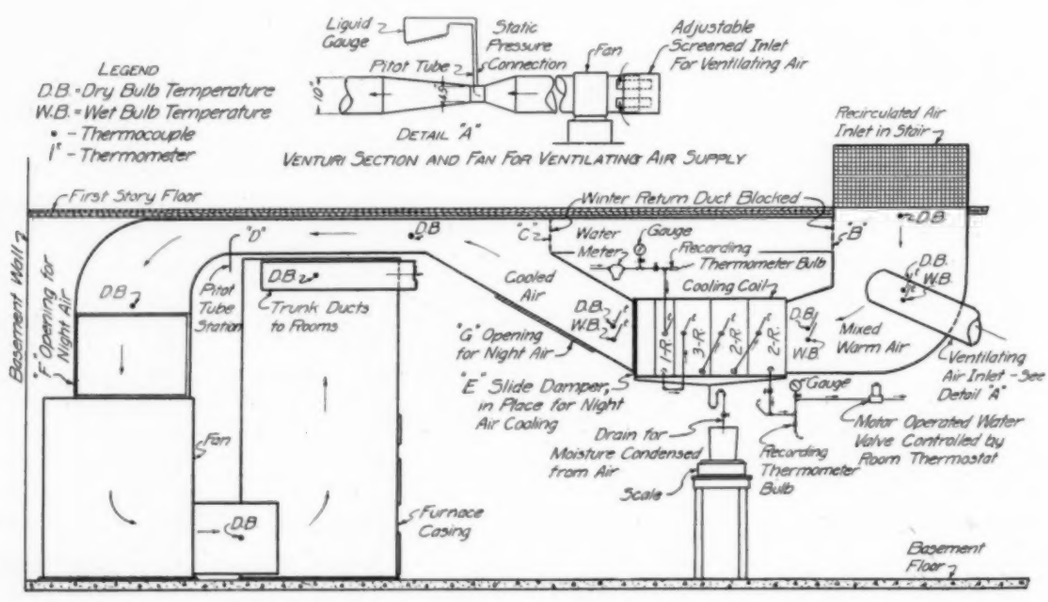


Fig. 3—Diagram of cooling plant with water cooling coil

by raising the lower sash to the full extent. Two windows which were opposite registers and one window at the second floor stair landing remained closed. For most of the tests the Residence was operated on the schedule as given:

The second story windows and the attic and basement doors were closed at 7 a. m. and the dampers were changed so that the fan, which had been delivering outdoor air through the system, started delivering recirculated air and the outdoor air admitted for ventilation. The former was equivalent to 4.4 recirculations of the air in the house, and the latter was equivalent to one air change per hour, making a total of 5.4 air changes per hour, delivered by the fan. The fan was allowed to run continuously during the day. When the temperature of the indoor air on the second story rose to 81 F the motor driven valve actuated by the thermostat admitted water to the cooling coil. The cooling plant was allowed to operate with thermostatic *on* and *off* control maintaining 81 F on the second story until the effective temperature outdoors became equal to the effective temperature on the second story indoors. The water valve was then closed; the second story windows and attic door were opened; and the dampers were set and the basement door opened, so that the fan delivered outdoor air through the duct system, the fan continuing to run until 7 a. m. The fan delivery was 2300 cfm or 9.74 air changes per hour.

During the latter part of the season this schedule was modified by maintaining an effective temperature of approximately 74 F instead of a dry-bulb temperature of 81 F. This was accomplished by controlling the plant manually and starting the flow of water through the coil whenever the relative humidity increased sufficiently so that with the prevailing dry-bulb temperature the effective temperature rose above 74 F.

Results of Tests

General Conditions. The operating characteristics of the cooling plant and a comparison of the actual and calculated cooling loads for the house can best be illustrated by the results obtained on a typical day. For this purpose a test made on August 2, 1935, was selected and the results are shown in Table 1 and Fig. 4. General results from all tests are given in Table 2.

On the typical day selected, the outdoor temperature was 95.0 F at 2 p.m. and reached a maximum of 96.0 F at 2:30 p.m. At this time the house was being operated with a constant dry-bulb temperature of approximately 80 F, and the windows on the second story had been

Table 1—Typical Operating Data and Results Obtained by Cooling With Water, at 2:00 P. M. on August 2, 1935[a]

1. Outdoor air	D.B.[b] 95.0 F, W.B. 78.6 F, D.P. 72.5 F
Humidity	R.H. 48.5%, S.H. 120.8 grains per pound dry air
2. Indoor air, aver. breathing level temperature	1st story 79.1 F, 2nd story 80.5 F
3. Indoor air, house aver. at breathing level	D.B. 79.8 F, W.B. 70.9 F, D.P. 67.2 F
Humidity	R.H. 65%, S.H. 99.8 grains per pound dry air
4. Indoor air, entering return grille	D.B. 77.7 F, W.B. 69.8 F, D.P. 66.2 F
Humidity	R.H. 67.5%, S.H. 96.8 grains per pound dry air
5. Ventilating air	D.B. 91.6 F, W.B. 76.2 F, D.P. 70.1 F
Humidity	R.H. 49.5%, S.H. 111.0 grains per pound dry air
6. Mixed air entering cooling coil	D.B. 80.3 F, W.B. 70.7 F, D.P. 66.5 F
Humidity	R.H. 62.8%, S.H. 97.5 grains per pound dry air
7. Mixed air leaving cooling coil	D.B. 65.8 F, W.B. 64.7 F, D.P. 64.1 F
Humidity	R.H. 94.0%, S.H. 89.7 grains per pound dry air
8. Air temperature drop through cooling coil, F	14.5
9. Temperature of cooled air leaving registers, 1st and 2nd story aver., F	70.2
10. Air temperature rise in ducts and casing, F	4.4
11. Basement air temperature at breathing level, F	75.2
12. Quantity of air circulated through wet coils	1,277 cfm or 5,547 lb of dry air per hour
Density of air, pound, per cubic foot	0.0724
13. No. of house air recirculations per hour	5.4
14. Ventilating air	238 cfm or 1005 lb of dry air per hour
Density of air, pounds, per cubic foot	0.0704
15. Cooling coil	gross face area 4.33 sq ft
	net free area 1.76 sq ft
Surface of cooling coil, square feet	429
Air velocity, feet per minute	gross face 295, net face 359, free area 726
16. Moisture condensed from air, pounds per hour	5.83
17. Heat given up by the air; total	25,440 Btu per hour
Heat due to moisture in air	6,120 Btu per hour; 24.0% of total heat absorbed
Sensible heat	19,320 Btu per hour; 76.0% of total heat absorbed
18. Water temperature through cooling coil, F	Inlet 58.3, Outlet 66.2, Rise 7.9
19. Rise in water temperature through coil, F	One row 0.8, Four rows 4.2, Six rows 5.5
	Eight rows 7.9
20. Water pressure at coil, pounds per square inch	Inlet 20.5, Outlet 20.0
21. Quantity of cooling water per hour	Pounds 3000.6, Gallons 360
22. Heat absorbed by water passing through cooling coil, Btu per hour	23,700
23. Recirculating fan data	Speed 477 rpm
Motor	Size ¼ hp, Measured power rate 0.44 kw
24. Static pressure loss through coils	Wet 0.28 in. water, Dry 0.23 in. water
25. Total resistance of system	0.51 in. water

[a]Test number 13, series 1-35.
[b]Abbreviations used: D.B.=Dry-Bulb temperature; W.B.=Wet-Bulb Temperature; D.P.=Dew Point temperature; R.H.=Relative Humidity; S.H.=Specific Humidity.

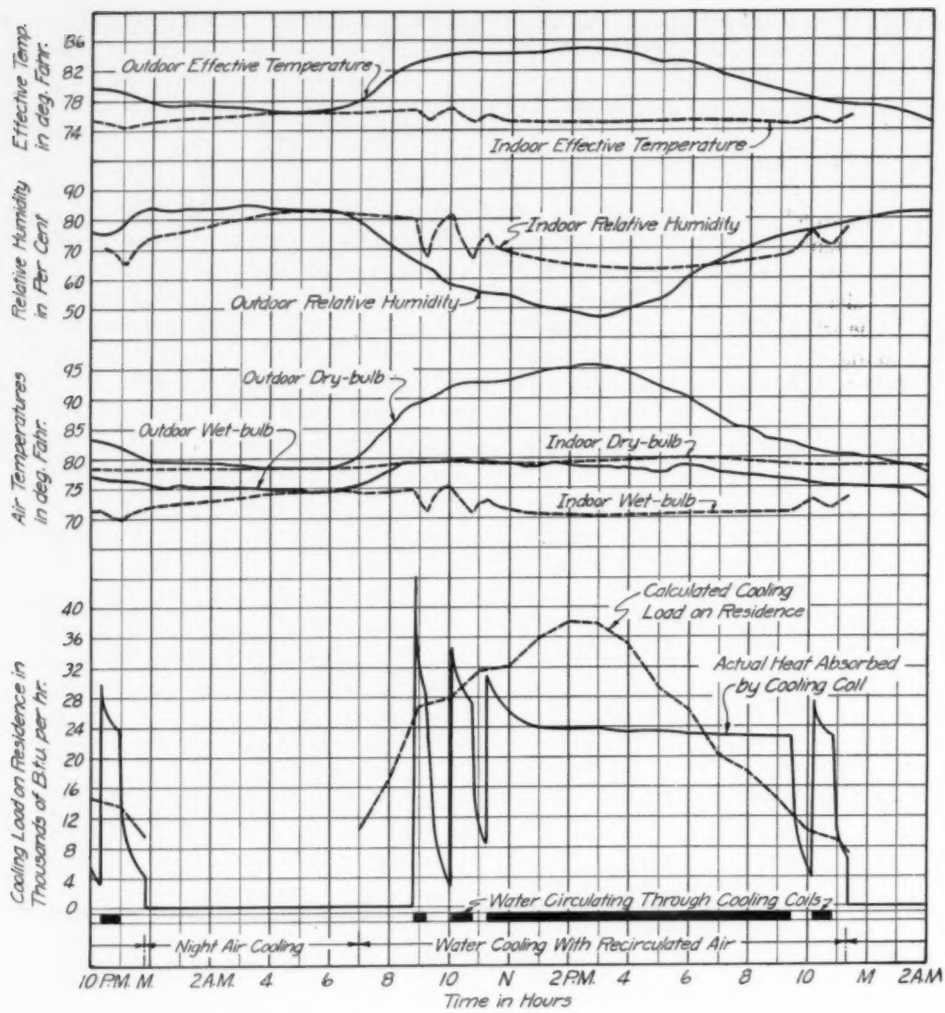

Effective Temp. in deg. Fahr.
Outdoor Effective Temperature
Indoor Effective Temperature
Relative Humidity in Per Cent
Indoor Relative Humidity
Outdoor Relative Humidity
Air Temperatures in deg. Fahr.
Outdoor Dry-bulb
Outdoor Wet-bulb
Indoor Dry-bulb
Indoor Wet-bulb
Cooling Load on Residence in Thousands of B.t.u. per hr.
Calculated Cooling Load on Residence
Actual Heat Absorbed by Cooling Coil
Water Circulating Through Cooling Coils
Night Air Cooling
Water Cooling With Recirculated Air
10 P.M. M. 2 A.M. 4 6 8 10 N 2 P.M. 4 6 8 10 M 2 A.M.
Time in Hours

Fig. 4—Actual and calculated cooling load on residence and air temperatures, Test No. 13, Series 1-35, August 2, 1935; with night air cooling

opened and outdoor air circulated on the previous night. The air conditions at different locations are given in the first eleven items of Table 1. The dry-bulb temperature on the second story was only 0.6 F higher than that on the first, thus indicating a satisfactory balance of the cooling on the two stories. The temperature of the cooled air leaving the registers was approximately 70 F, and no difficulty was experienced from drafts in the rooms. The rise in temperature of the air passing through the furnace casing and ducts was 4.4 F. The quantity of air circulated was 1347 cfm when the coils were dry. Increased frictional resistance when condensation was present on the coil surfaces, however, decreased this amount to 1277 cfm. Since part of the coil surfaces were always wet during actual operating periods, all calculations were based on 1277 cfm for the volume of air circulated at the density of 0.0724 lb per cu ft. With this amount of air, which represented 5.4 recirculations per hour, the velocity through the net face area was 359 fpm and the temperature drop through the coil was 14.5 F. This corresponded closely with the 365 fpm and the 15.0 F drop used for the selection of the coils. The free area velocity of 726 fpm did not prove to be sufficient to carry any condensed moisture away from the surfaces of the cooling coil.

Cooling Load. Since the cooling coil was well lagged with corkboard to prevent heat gain, it was possible to obtain the actual cooling load either from the heat given up by the mixture of air and water vapor or from the heat absorbed by the water passing through the coil. Considerable difficulty, however, was experienced in obtaining a heat balance between these two quantities. The discrepancy was approximately 20 per cent. It was found, by making a complete traverse in the duct on both sides of the coil, that both the wet-bulb and dry-bulb temperatures varied from point to point in the cross-section of the duct. By comparing the results of these traverses with the averages of the temperatures obtained from the readings of the wet- and dry-bulb thermometers at the two reading stations on each of the upstream and downstream sides of the coil, it became evident that a correction of —0.1 had to be added to the average dry-bulb reading on the upstream side and one of +1.0 F to that on the downstream side. Also a correction of +0.1 F had to be added to the average wet-bulb reading on the upstream side and one of +0.5 to that on the downstream side. In addition to these corrections it was found necessary to make a correction of —0.4 F to

Table 2—Complete Data and Results for Tests

Date 1935	Test No.	Series No.	WEATHER DATA: Degree-Hours Above 85 Deg	Degree-Hours Above 90 Deg	Sun Hour: Min	Outdoor Air: Max. Temp. During Test F	Outdoor Air: Min. Temp. Previous to Test F	Outdoor Air: Average During Period Requiring Cooling with Water Temp. F	Outdoor Air: Average During Period Requiring Cooling with Water Hum. %	Indoor Air Conditions: At End of Night Cooling Temp. F	Indoor Air Conditions: Average During Period Requiring Cooling with Water Temp. F	Indoor Air Conditions: Average During Period Requiring Cooling with Water Hum. %	Temperature Difference: Out-door Max. to Average Indoor F	Temperature Difference: Average Out-door to Average Indoor F	OPERATION OF THE FAN: Night Air Cooling Previous to Test Dura-tion Hours	Night Air Cooling Previous to Test Power Kw Hr	Recirculation Previous to Test Dura-tion Hours	Recirculation Previous to Test Power Kw Hr	Recirculation During Test Period Dura-tion Hours	Recirculation During Test Period Power Kw Hr	OVERALL TEST PERIOD: Start of Cooling with Water to Start of Night Air Cooling Start	End	Dura-tion Hours	Water Circulation Through Cooling Coil: Time in Hours	Quan-tity in Gallons	Temp. at Inlet F	Temp. Rise Through Coil F	Total Moi-ture Con-densed Lb	Heat Absorbed by Cooling Coil During Overall Test Period, Btu: Load Due to Moi-sture	Sensible	Total
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
July 18	2	I-35	65.20	20.56	14:45	94	67	87.8	55.6	73.0	79.3	62.7	14.7	8.5	11.50	6.3	9.05	3.3	4.78	2.0	4:04P	8:50P	4.78	4.77	1784	57.7	6.7	15.28	16,050	83,613	99,663
19	3	I-35	32.00	4.64	8:20	92	70	89.4	49.3	76.0	79.8	64.5	12.2	9.6	10.17	5.4	7.45	2.8	2.55	1.1	2:27P	5:00P	2.55	2.55	860	57.7	7.6	7.88	8,280	46,212	54,492
21	4	I-35	7.84	0	11:06	87	69	82.8	76.7	73.7	78.9	70.6	8.1	3.9	9.33	5.1	7.68	3.8	4.65	1.7	4:41P	9:20P	4.65	3.15	1175	58.3	8.4	22.30	23,420	58,732	82,152
22	5	I-35	2.56	0	10:10	86	73	83.9	71.5	76.1	79.4	70.2	6.6	4.5	9.75	5.2	7.63	2.9	5.28	2.0	2:43P	8:00P	5.28	4.03	1503	58.1	8.1	30.32	31,840	69,775	101,615
25	6	I-35	19.36	0	12:54	89	75	87.7	64.7	77.0	79.7	67.4	9.3	8.0	11.92	6.0	6.62	2.6	2.88	1.3	1:37P	4:30P	2.88	2.88	1048	58.2	8.3	19.47	20,450	52,092	72,542
26	7	I-35	11.36	0	14:32	89	70	85.5	66.0	75.7	79.8	68.0	9.2	5.7	14.50	8.7	8.20	3.5	4.80	2.1	3:12P	8:00P	4.80	4.10	1476	58.3	8.2	21.92	23,030	77,830	100,860
27	8	I-35	15.92	0	12:49	88	69	83.6	71.2	75.4	78.8	68.9	9.2	4.8	11.00	6.6	6.58	2.8	7.92	3.6	1:35P	9:30P	7.92	6.32	2253	58.1	7.8	32.62	34,270	112,214	146,484
28	9	I-35	36.40	3.92	11:45	92	74	86.9	80.9	76.2	79.3	70.1	12.7	7.6	9.50	5.5	6.93	3.2	8.57	3.8	1:56P	10:30P	8.57	6.53	2432	58.3	8.2	47.06	49,420	116,794	166,214
30	10	I-35	60.64	16.40	14:24	94	65	88.0	68.7	73.2	79.9	67.3	14.1	8.1	10.50	6.2	8.68	3.8	6.32	2.8	3:41P	10:00P	6.32	4.07	1481	58.2	8.9	23.67	24,860	84,966	109,826
31	11	I-35	71.20	22.96	12:08	95	76	88.9	68.1	79.7	79.5	66.4	15.5	9.4	9.00	5.3	2.08	0.8	14.42	6.6	9:05A	11:30P	14.42	12.10	4266	57.5	8.9	93.14	97,850	218,634	316,484
Aug. 1	12	I-35	80.96	29.12	11:20	96	74	89.0	64.0	78.3	79.7	68.2	16.3	9.3	7.50	4.5	2.85	1.3	14.00	6.4	9:51A	11:51P	14.00	11.33	3997	58.2	8.2	66.06	69,350	203,874	273,224
2	13	I-35	84.32	31.92	13:40	96	76	89.8	61.7	78.8	79.7	68.1	16.3	10.1	7.15	4.1	1.85	0.9	14.50	6.8	8:51A	11:21P	14.50	11.93	4350	58.3	7.9	60.37	63,400	223,054	286,454
3	14	I-35	8.40	0	12:46	88	74	84.4	71.8	77.5	79.7	77.2	8.3	4.7	7.65	4.4	4.72	2.2	8.70	4.0	11:48A	8:30P	8.70	3.48	1276	58.3	9.1	10.45	10,970	85,854	96,824
4	15	I-35	34.88	1.12	14:14	91	69	86.5	58.6	77.5	79.8	63.2	11.2	6.7	10.50	6.3	8.25	3.7	4.25	2.0	3:15P	7:30P	4.25	3.20	1200	58.3	7.4	4.25	4,460	69,540	74,000
5	16	I-35	26.24	2.32	9:13	91	70	76.5	87.8	75.2	80.2	74.0	10.8	—3.7	11.50	6.7	6.73	3.0	3.77	1.8	1:44P	5:30P	3.77	0.35	133	58.2	9.9	c	.....	.....	10,949
6	17	I-35	65.52	19.12	14:09	94	72	87.2	71.3	75.9	79.2	69.3	14.8	8.0	13.50	8.4	7.12	3.3	9.38	4.4	2:07P	11:30P	9.38	7.25	2711	58.5	8.3	50.78	53,350	134,230	187,580
7	18	I-35	1.92	0	13:21	86	76	84.6	71.6	77.9	80.0	75.1	6.0	4.6	7.50	4.7	3.65	1.8	7.85	3.5	10:39A	6:30P	7.85	1.80	704	58.8	8.9	c	.....	.....	52,243
9	19	I-35	18.00	0	13:40	88	68	81.6	79.1	73.2	80.6	71.5	7.4	1.0	12.00	7.5	11.82	5.5	2.00	1.0	6:49P	8:49P	2.00	0.38	147	58.6	9.1	c	.....	.....	11,160
10	20	I-35	14.96	0	12:46	89	70	85.7	65.1	76.2	80.1	71.2	8.9	5.6	10.18	6.2	8.50	4.1	4.25	1.9	3:50P	7:45P	4.25	1.82	667	58.5	8.6	c	.....	.....	47,816
11	21	I-35	46.88	5.44	11:05	92	70	87.4	66.6	75.5	79.8	67.1	12.2	7.6	11.25	7.0	6.90	3.2	7.60	3.6	1:54P	9:30P	7.60	3.92	1468	58.5	8.1	12.60	13,240	85,904	99,144
12	22	I-35	35.04	4.40	14:26	92	72	87.2	58.4	76.4	80.3	69.0	11.7	6.9	9.50	6.0	4.78	2.1	6.72	3.1	11:47A	6:30P	6.72	2.07	766	58.3	9.1	3.35	3,520	54,584	58,104
15	23	II-35	0	0	13:30	82	68	80.6	75.5	72.7	76.1	73.3	5.9	4.5	13.50	7.6	8.40	3.9	3.10	1.3	3:24P	6:30P	3.10	1.72	639	58.6	8.0	4.00	4,200	38,440	42,640
16	24	II-35	3.20	0	13:27	87	68	83.2	70.5	73.2	76.3	81.0	10.7	6.9	12.50	6.3	3.43	1.6	8.57	3.6	10:26A	7:00P	8.57	3.62	1390	58.3	8.0	11.45	12,030	80,690	92,720
18	25	II-35	2.48	0	13:04	86	68	84.1	72.6	73.9	76.5	78.7	9.5	7.6	12.25	6.0	4.58	2.0	6.17	2.7	11:50A	6:00P	6.17	3.20	1182	58.4	8.2	16.60	17,430	63,340	80,770
19	26	II-35	2.80	0	8:30	86	70	84.2	72.0	74.3	76.4	83.5	9.6	7.8	13.00	6.5	3.73	1.7	8.27	3.5	10:44A	7:00P	8.27	4.45	1651	58.3	7.9	26.23	27,570	81,134	108,704
20	27	II-35	1.12	0	10:56	86	70	83.3	76.8	74.5	76.7	77.6	9.3	6.6	12.00	5.9	6.37	2.8	8.10	3.5	1:22P	9:28P	8.10	5.22	1718	58.1	8.1	31.95	33,550	82,442	115,992

Note: Test No. 1 was omitted on account of incomplete data.

[c] Test too short to permit accurate determination of weight of moisture condensed.

account for radiation received by the wet-bulb thermometers on the upstream side. No radiation correction was necessary on the downstream side, since the air was very nearly saturated and the wet-bulb temperature was practically the same as the dry-bulb temperature of the air and surrounding surfaces. By using these corrected wet-bulb readings to determine the enthalpy of the moist air entering and leaving the coil it was possible to obtain a heat balance between the air and water within approximately 8 per cent. This method of calculation, however, does not show the distribution between sensible and latent heat loads. This distribution was obtained, as shown in Item 17, Table 1, by using the corrected values for the dry-bulb temperatures, and by multiplying the weighed amount of condensation from the coil by a constant representing the heat given up by the change in moisture content of the air per pound of water vapor condensed. This latter included the latent heat and superheat in the water vapor condensed, and the change in the superheat of the water vapor remaining in the air after passing the cooling coil, and amounted to 1,050 Btu per pound of vapor condensed. The total of the heat given up by the air as computed by this method was within 6 per cent of the calculated heat absorbed by the water. For the purpose of analysis, and in the general results shown in Table 2, the cooling load calculated from the water circulated through the coil, as shown in Item 22, Table 1, was accepted as correct. The latent heat load was calculated from the weighed amount of moisture condensed from the air, and the sensible heat load was obtained by difference. On all tests having a duration exceeding 4 hours, the moisture load varied from 20 to 31 per cent of the total load.

It is not generally recognized that wet-bulb readings are subject to a radiation correction that can not be eliminated by any processes of shielding or increasing the velocity of the air passing over the instrument. This cor-

rection is a minimum in saturated air, where the wet-bulb depression is zero, and increases as the air becomes drier and the wet-bulb depression increases. Owing to this fact, and to point to point variations in both wet- and dry-bulb temperatures in the cross-section of a duct, it should be emphasized that heat load determinations based on the air side of a system alone should be accepted with extreme caution unless some independent check on the validity of the results is available.

Operating Characteristics with Constant Dry-bulb Temperature

The operating characteristics with a constant dry-bulb temperature in the rooms of approximately 80 F are shown in Fig. 4, for a day on which the outdoor temperature rose to a maximum of 96 F. During the night before, when the second story windows were opened and outdoor air was circulated, the indoor dry-bulb temperature dropped to 78 F and remained at this value until 7:00 a.m., when the windows were closed and the dampers were changed to recirculate the air in the house. The dry-bulb temperature rose to 79 F at 8:50 a.m. at which time the thermostat opened the water valve. The plant then operated intermittently until 11:20 a.m., and continuously from 11:20 a.m. to 9:30 p.m. maintaining the dry-bulb temperature between 79 and 80 F.

At 8:50 a.m. the wet-bulb temperature was 75 F, corresponding to a relative humidity of 80 per cent. When the plant started the relative humidity dropped to 67 per cent, but rose again to 81 per cent almost immediately after the water valve closed. This alternate decrease and increase of relative humidity in the house was characteristic of the intermittent operation of the plant. When the plant operated continuously, however, as from 11:20 a.m. to 9:30 p.m., the relative humidity stabilized at between 63 and 66 per cent, representing an effective temperature of approximately 75 F. During the intermittent periods the effective temperature was at times as high as 77 F. That is, on a warm day, when the plant operated continuously, conditions were just on the upper borderline for comfort, but during the periods of intermittent operation the effective temperature was distinctly too high for comfort. The significance of this type of operation on a milder day will be referred to later, but conditions shown in Fig. 4 indicated that for 58 F service water, with which it was not found possible to obtain a relative humidity lower than 62 per cent, the dry-bulb temperature should be maintained somewhat lower than 80 F.

The calculated cooling load was computed by the method outlined in a previous paper.[6] The calculated load was greater than the actual load during the period from 11:15 a.m. to 6:30 p.m., rising to a maximum value of 38,000 Btu per hour at 2:30 p.m. as compared with an actual load of 24,000 at the same time. After 6:30 p.m. the calculated load became less than the actual load. This tendency for the actual and calculated load curves to cross at approximately 6:30 p.m. was also noted on the previous work with ice cooling and with the mechanical refrigerating unit.

During the periods of intermittent operation the actual cooling load curve showed high peaks at the start of each operating period. These peaks correlated with periods of high indoor relative humidity, indicating that periods of high wet-bulb temperature for the air entering the coil were accompanied by corresponding periods of comparatively high heat transmission for the coil. An explanation for this correlation is offered by Fig. 5.

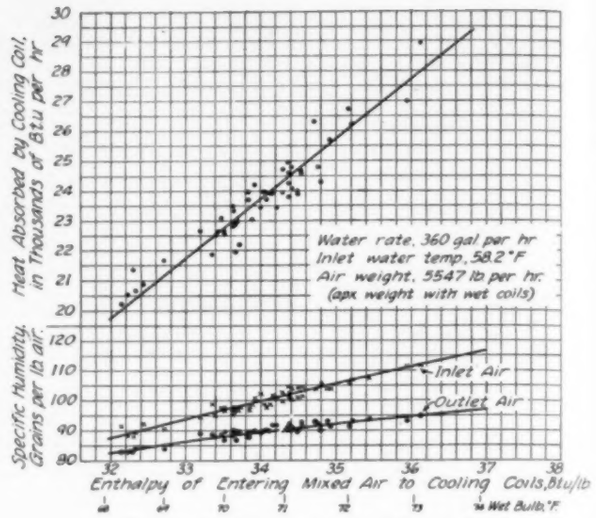

Heat Absorbed by Cooling Coil, in Thousands of Btu per hr
Water rate, 360 gal per hr
Inlet water temp, 58.2°F
Air weight, 5547 lb per hr
(apx weight with wet coils)
Specific Humidity, Grains per lb air
Inlet Air
Outlet Air
Enthalpy of Entering Mixed Air to Cooling Coils, Btu/lb
Wet Bulb, °F

Fig. 5—Performance of cooling coils

Heat Transmission of Coils. The upper curve in Fig. 5 shows that the heat absorbed by the coil was practically a linear function of the enthalpy of the entering air. C. J. Scanlan[7] has shown this to be true for a different type of coil when the velocity of the air and the mean temperature of the refrigerant in the coil were maintained constant. The deviations of the points from the mean curve shown in Fig. 5 can therefore be explained by variations in mean water temperature, and in the weights of air and water circulated under the conditions of the tests. The maximum deviation shown, however, was only 6 per cent.

During these tests a constant indoor dry-bulb temperature was maintained, resulting also in a practically constant dry-bulb temperature for the air entering the coil. Hence, periods of high relative humidity also represented periods of high wet-bulb temperature with corresponding high enthalpy for the air entering the coil; and since Fig. 5 shows that high heat transmission accompanied high enthalpy for the air entering the coil, it also serves to explain the fact that the peaks in the load curve in Fig. 4 occurred at times corresponding to high indoor relative humidity.

Although the same type of curve as that shown in Fig. 5 also applies to the evaporator coil used in connection with the mechanical refrigerating unit for the studies in the summer of 1934, this plant did not show the high peaks in the load curve which were characteristic of the water cooling plant. In the case of the evaporator coil the heat transmission at the time of starting was limited by the amount of refrigerant that could enter the coil. This refrigerant would tend to superheat, thus increasing the temperature of the coil surface and offsetting the tendency for the heat transmission to increase with an increase in the wet-bulb temperature of the entering air.

The curves in Fig. 6 show that during periods of continuous operation, both in the case of the water coil used

[6]Loc. cit. Note 3.

[7]Performance of Extended Cooling Surfaces, by C. J. Scanlan, *Refrigerating Engineering*, Vol. 27, No. 4, April, 1934, pp. 197-199.

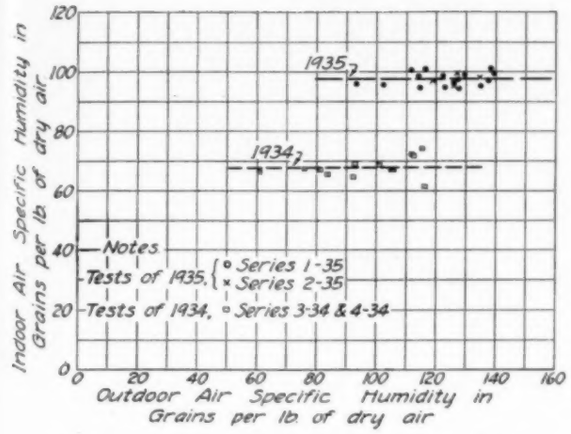


Fig. 6—Specific humidity of indoor air resulting from operation with two types of cooling systems

in the study in 1935 and in the case of the mechanical refrigerating unit used in the study of 1934, the indoor specific humidity maintained was dependent only on the temperature of the medium used and the character of the cooling coil and was independent of the amount of water vapor in the outdoor air. Since in both cases a constant indoor dry-bulb temperature of 80 F was maintained, the specific humidity is also representative of the indoor relative humidity. That is, the water coil used in 1935 with a mean water temperature of approximately 62 F maintained a constant indoor relative humidity of 63 per cent during periods of continuous operation, while the evaporator coil used in 1934 with a mean temperature of approximately 45 F for the refrigerant maintained a constant relative humidity of 45 per cent.

During periods of operation the ventilating air from outdoors was mixed with the recirculated air from the house just before entering the cooling coil. The moisture content of the outdoor air therefore directly influenced that of the mixed air entering the coil. The lower curves in Fig. 5 indicate that the enthalpy of the entering air increased as the specific humidity increased, resulting in an increase in the heat transmission for the coil. At the same time the specific humidity of the air leaving the coil increased, but not to as great an extent as that of the inlet air. This indicates that a part, if not all, of the increase in heat transmission was utilized in increasing the amount of condensation as the specific humidity of the outdoor air and hence that of the air entering the coil, was increased. Thus the increasing heat transmission of the coil tended to compensate for increases in the outdoor specific humidity, and, as a result, also tended to maintain a constant indoor relative humidity during periods of continuous operation, as shown in Fig. 6.

Operating Characteristics with Constant Effective Temperature

Fig. 7 shows the performance of the Residence on two mild days, during which the operation of the plant was intermittent and no long periods of continuous running occurred. The left hand side shows the operation on a day on which the outdoor temperature rose to a maximum of 87 F and a constant indoor dry-bulb temperature of approximately 80 F was maintained. Owing to the short operating periods, the indoor relative humidity ranged from 68 to 80 per cent with corresponding indoor effective temperatures of from 76 to 77.5 F. At no time could the conditions be regarded as comfortable. A study was therefore made on a similar day on which the maximum outdoor temperature rose to 86 F and during which the plant was manually controlled to maintain an indoor effective temperature not to exceed 76 F. The results of this study are shown in the right hand side of Fig. 7. The second story windows were closed at 7:00 a.m. and

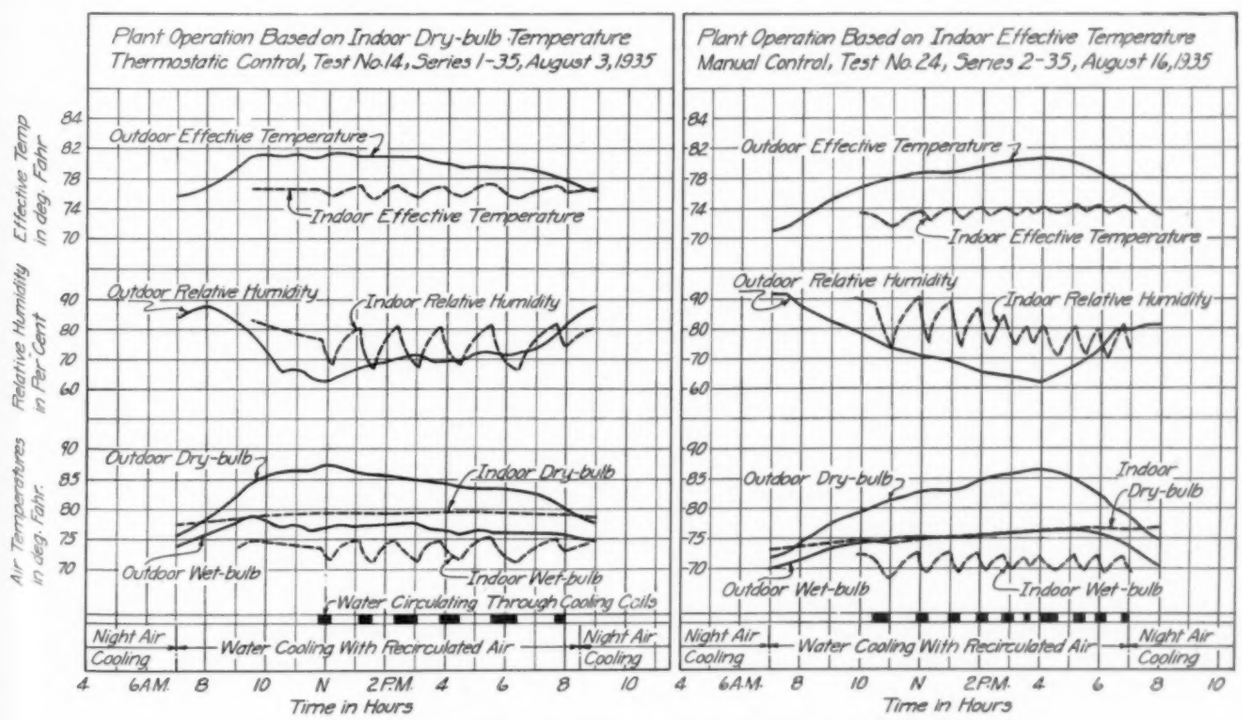

Plant Operation Based on Indoor Dry-bulb Temperature
Thermostatic Control, Test No. 14, Series 1-35, August 3, 1935
Plant Operation Based on Indoor Effective Temperature
Manual Control, Test No. 24, Series 2-35, August 16, 1935
Effective Temp in deg. Fahr.
Outdoor Effective Temperature
Indoor Effective Temperature
Relative Humidity in Per Cent
Outdoor Relative Humidity
Indoor Relative Humidity
Air Temperatures in deg. Fahr.
Outdoor Dry-bulb
Indoor Dry-bulb
Outdoor Wet-bulb
Indoor Wet-bulb
Water Circulating Through Cooling Coils
Night Air Cooling
Water Cooling With Recirculated Air
Night Air Cooling
4 6A.M. 8 10 N 2P.M. 4 6 8 10
Time in Hours

Fig. 7—Indoor and outdoor temperature conditions with cooling plant operation based on indoor dry-bulb temperature and indoor effective temperature

at 10:00 a.m. the indoor dry-bulb temperature was 75 F and the relative humidity was 90 per cent, corresponding to an effective temperature of 74 F. The plant was then started and the relative humidity decreased to 74 per cent giving an effective temperature of 72 F at 11:00 a.m. at which time the plant was stopped. Subsequent to this the plant was started manually whenever the effective temperature approached 74 F with the prevailing dry-bulb temperature and was stopped whenever the effective temperature dropped to 73 F. With this method of operation the indoor dry-bulb temperature gradually increased to 77 F and the relative humidity decreased to vary between 70 and 80 per cent during the on- and off-periods of operation. By this means comparatively comfortable conditions were maintained in the house during the entire day.

The results of these studies indicate that it would be desirable to develop a means of control operating directly on effective temperature. With 58 F service water available, and with a constant dry-bulb temperature of 80 F maintained, on warm days, when the maximum outdoor temperature rose above 90 F, and when the plant could operate continuously, a material improvement in atmospheric conditions was effected that would be acceptable to the majority of users, even though optimum conditions were not obtained. On mild days, however, this could not be accomplished with a constant dry-bulb temperature of 80 F, but by setting the thermostat to maintain approximately 76 F acceptable conditions could be maintained. The results further indicated that 60 F is probably the upper practical limit for the temperature of the available cooling water. With higher initial water temperatures the amount of dehumidification or reduction in indoor relative humidity would be very small. Consequently, room temperature considerably lower than 80 F would have to be maintained and the amount of coil surface required would be excessive.

Factors Affecting the Selection of Cooling Coils. In selecting the cooling coils required to absorb the maximum cooling load on the Research Residence, it was found that there was considerable latitude in the choice, provided no restrictions were placed on the amount of cooling water or the amount of coil surface used. The cooling load was estimated at 20,000 Btu per hour sensible heat and 7,000 Btu per hour latent heat. With 80 F maintained in the rooms, the restriction of 70 F for the temperature of the air leaving the registers, together with the known rise of 4 F in the duct system, determined that the temperature drop of the air passing through the coil should be 15 F; or from 81 F to 66 F. This drop in temperature, together with the sensible heat load, limited the air requirement to 1300 cfm. A net face velocity of 365 fpm permitted the use of an air duct of reasonable dimensions, and thus fixed the face area of the coil. The freedom of choice then proved to be in the amount of coil surface, or the number of rows of coil to be used.

The curves in Fig. 8 were computed from the data furnished by the manufacturer of the coils, and indicate that the required temperature drop in the air could be obtained either by the use of a large amount of cooling water with a small amount of coil surface, or by a small amount of water in connection with a large amount of coil surface. Furthermore, the resistance to the flow of

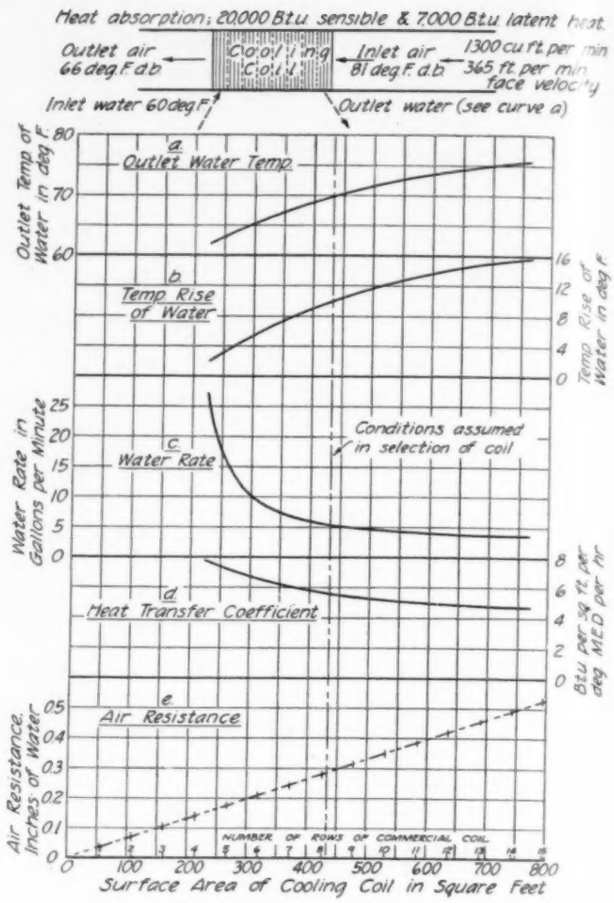

Heat absorption: 20000 Btu sensible & 7000 Btu latent heat
Outlet air 66 deg F db
Cooling Coil
Inlet air 81 deg F db
1300 cu ft per min
365 ft per min face velocity
Inlet water 60 deg F
Outlet water (see curve a)
a Outlet Water Temp
b Temp Rise of Water
c Water Rate
d Heat Transfer Coefficient
e Air Resistance
Conditions assumed in selection of coil
Outlet Temp of Water in deg F
Temp Rise of Water in deg F
Water Rate in Gallons per Minute
Btu per sq ft per deg MED per hr
Air Resistance, Inches of Water
NUMBER OF ROWS OF COMMERCIAL COIL
Surface Area of Cooling Coil in Square Feet

Fig. 8—Computed performance characteristics for one type of cooling coil

air increased rapidly as the amount of surface, or number of rows of coil increased. In addition to the possible limit imposed on the air delivery by the higher resistance, the use of a large amount of surface has the further disadvantage of high first cost. On the other hand, the use of a small amount of coil surface has the disadvantage of high operating cost due to the amount of water used. Under these conditions a compromise is necessary. In the case of the Research Residence, this was effected by selecting 8 rows of coils. As shown by the water rate curve in Fig. 8, this determined a water rate such that a decrease of one or two rows would have resulted in an appreciable increase in water consumption, while an increase of one or two rows would not have resulted in an appreciable decrease in water consumption.

The resistance offered by the coil itself to the flow of water was only 0.5 lb per square inch as shown in Item 20 of Table 1. The drop in pressure from the city main to the entrance of the coil, however, was approximately 35 lb per square inch through the ¾ in. line from the main to the coil. This loss in pressure may in some cases be the limiting factor in determining the amount of water available for cooling purposes. The estimated resistance to flow of air of the 8 row coil was 0.29 in. of water.

Under normal conditions of winter operation, the total resistance of the system, including friction and shock losses, was 0.18 in. of water, and the fan as installed delivered 1675 cu ft of air per minute. For the summer work, however, in order to facilitate testing, particularly

in connection with the measurement of the quantity of air delivered, the cooling coil was located in a by-pass in the main return air duct, and the two auxiliary returns were blocked, thus causing all of the return air to pass through the coil and the single main return duct. In addition, the delivery ducts to the sun room and third story were blocked, and it was necessary to readjust the dampers in the remaining delivery ducts in order to balance the cooling on the first and second stories. These changes had the effect of increasing the total resistance of the system without the coil to a value of 0.28 in. of water with 1347 cu ft of air flowing per minute. As shown in Item 24, Table 1, the measured resistance of the dry coil with this amount of air flowing was 0.23 in. of water. The latter was greater than the total resistance of the system during winter operation, and was comparable with that of the system without the coil in the case of summer operation. The total resistance of the system with the coil in place was 0.51 in. of water. Under these conditions it was found necessary to install a larger fan for the summer work.

When the surface of the coil became wet with water condensed from the air, the measured resistance of the coil alone increased from 0.23 in. of water to 0.28 in. of water; or 22 per cent. With the speed of the fan maintained constant, the increase in resistance resulting from the collection of moisture on the coil surfaces was sufficient to cause variations in the amount of air flowing depending on the amount of surface wetted. The amount of air delivered through the dry coil was 1347 cfm, and with maximum condensation occurring it was 1277 cfm; or a reduction of 5.2 per cent.

If the cooling coil had been located in the return duct just above the fan inlet without further changes in the winter system, it is possible that the total resistance would have been increased to only 0.41 in. of water instead of to 0.51 in. of water. Even this, however, is more than double the normal resistance for winter operation, and it is doubtful whether the fan used for winter operation could have been retained. In cases where the temperature of the available service water is above 55 F, the resistance of the coils and the possibility of the need for a larger fan for summer cooling than for winter heating should be given careful consideration in the design of forced-air systems that are to be used for both summer cooling and winter heating.

Summary of Seasonal Results. Table 3 gives a summary of the total quantities obtained for the season of 1935. The total of 1081.8 degree-hours above 85 F indicates that this season was mild as compared with those for 1934, 1933, and 1932, for which the degree-hours above 85 F were 2657.5, 2309.3 and 1470.7 respectively. This was caused by the comparatively small number of days on which the outdoor temperature rose above 90 F. The hours above 85 F for this season were 322.6 as compared with 481.5, 493.2 and 329.1 for 1934, 1933 and 1932, while the hours above 90 F were only 82.5 as compared with 224.1, 208.4 and 121.8 respectively for the previous seasons. The severity of the season as measured by degree-hours is apparently determined largely by the total number of days on which the maximum temperature exceeds 90 F, since the higher numbers of degree-hours are always accompanied by the higher numbers of hours above 90 F. While the 1935 season was mild from the standpoint of outdoor temperatures, it was characterized by unusually high outdoor humidity. This is indicated to a certain extent by Fig. 6 from which it may be observed that the outdoor specific humidity ranged from 92 to 140 grains per pound of dry air in 1935 as compared with a range of from 60 to 118 grains per pound for 1934.

Table 3—Summary of Results of Tests Using Water for Cooling and Using Night Air Cooling for Entire Season of 1935

Weather Data		
1.	Total hours above 85 F for season of 1935	322.6
2.	Total hours above 90 F for season of 1935	82.5
3.	Total degree-hours above 85 F for season of 1935	1,081.8
4.	Total degree-hours above 90 F for season of 1935	174.1
Night Air Cooling		
5.	Total number of nights with night air cooling by fan	63
6.	Total running time for fan during night air cooling, hours	706
7.	Average rate of power input to fan during night air cooling, watts	443
8.	Total power input to fan during night air cooling, kwhr	313.1
Air Recirculation without Water Cooling		
9.	Total number of days with recirculation of house air by fan	59
10.	Total running time for fan during recirculation of house air, hours	474.8
11.	Average rate of power input to fan during recirculation without water cooling, watts	415
12.	Total power input to fan during recirculation of house air without cooling, kwhr	196.9
Air Recirculation with Water Cooling		
13.	Total number of tests with water cooling	32
14.	Total running time for fan during test period, hours	201.1
15.	Average rate of power input to fan during test period, watts	433
16.	Total power input to fan during test period, kwhr	87.1
Combined Totals		
17.	Total running time for fan including night air cooling, hours	1,381.8
18.	Total power input to fan including night air cooling, kwhr	597.1
19.	Total number of hours of test period for season	201.1
20.	Total number of hours of water circulation during test period	120.6
21.	Total quantity of cooling water, gallons	43,300
	cu ft	5,690

From Item 6, Table 3 it may be observed that the total time that the fan was running during periods when it was circulating air from outdoors at night was 706 hours. At the local rate for electrical current of 3.1 cents per kilowatt-hour prevailing in Urbana, Ill., the cost of operating the fan during these periods was 1.37 cents per hour. During the stand-by periods from 7:00 a.m. until the indoor temperature rose to 80 F the fan was allowed to recirculate the air in the house. As shown by Item 10 the total running time for the fan during these periods was 474.8 hours. During all of the time that cooling was demanded the fan was allowed to run irrespective of whether the water control valve was open or closed. The total time that the fan was running during these periods, as shown by Item 14, was 201.1 hours. The total time during which the fan was operated to recirculate the air in the house was therefore 675.9 hours, and the cost of operating the fan to recirculate the air in the house was 1.31 cents per hour. The total amount of water actually used during the total running time of 120.6 hours was 43,300 gal. At the prevailing rate of 33 cents per thousand gallons this represented an hourly cost of 11.8 cents per hour for water alone, or a total hourly cost of 13.1 cents for both water and electricity during the actual time when the water was running.

Owing to wide variations in seasonal demands and in local water and electrical rates, seasonal costs are comparatively meaningless. With restriction of due appreciation of their limitations, however, they are undoubtedly of some interest. During the part of the season over

which the plant was in operation, the total cost for electricity for operating the fan both to circulate air from outdoors at night and to recirculate the air in the house during the day was $18.52. The total cost for water was $14.29, and the cost for both electricity and water was $32.81. Although the cooling plant was not ready to operate before July 11, observations on the temperatures and conditions in the Residence were made dating from June 1. The first part of the summer, particularly during May, was unusually cool, and these observations indicated that between May 1 and July 11 only 8 days occurred on which any cooling whatever would have been required. If these days are included, a reasonable estimate of the cost of cooling for the season of 1081.8 degree-hours would be approximately $36.00.

Conclusions

The following conclusions may be drawn as applying to the Research Residence and the conditions under which the tests were conducted.

(1) Using water from the city mains at 58 F, it is possible to maintain an indoor dry-bulb temperature of 80 F with the outdoor temperature as high as 100 F. On days when the maximum outdoor temperature exceeds 90 F the plant will operate continuously over considerable periods of time and it is possible to maintain an indoor relative humidity of 63 per cent, with a resultant effective temperature of 75 F. While not representative of optimum comfort, these conditions do represent a material improvement in atmospheric conditions that would probably be acceptable to the majority of users.

(2) On days when the maximum outdoor temperature does not exceed 90 F the plant will operate intermittently at all times and the indoor relative humidity will exceed 63 per cent. Under these conditions the maintenance of an indoor dry-bulb temperature of 80 F will result in effective temperatures exceeding 75 F and conditions will not be satisfactory from the standpoint of comfort.

(3) On moderately warm days it is possible to operate the plant with 58 F water from the city mains so as to maintain effective temperatures not exceeding 74 F with indoor relative humidities ranging from 70 to 80 per cent, and to maintain acceptable conditions from the standpoint of comfort.

(4) With 58 F water from the city mains it is possible to obtain sufficient dehumidification to maintain 63 per cent relative humidity indoors. These results indicate that 60 F is probably the upper practical limit for the temperature of the available cooling water unless an excessive amount of coil surface is used, in order to maintain indoor dry-bulb temperatures as low as 75 F in severe weather.

(5) In designing a plant to operate on 58 F water from the city mains the resistance of the coils to the flow of air and the capacity of the fan available may become limiting factors in determining the amount of surface and character of the coil to be used.

(6) The resistance of the coil to the flow of water is very small, but the pressure loss in the line between the coil and the city main may be large enough to become a limiting factor in determining the amount of water that can be circulated through the coil.

Acknowledgments

The results presented in this paper were obtained in connection with the summer cooling investigation (1935) in the Research Residence[8], Fig. 1, at the University of Illinois, conducted by the Engineering Experiment Station of which M. L. Enger, Dean of the College of Engineering is the director, in the Department of Mechanical Engineering of which O. A. Leutwiler, Professor of Mechanical Engineering Design, is the head. These results will ultimately comprise part of a bulletin of the Engineering Experiment Station. Acknowledgment is also due to J. S. Cunningham, Research Assistant, for services rendered in connection with the investigation, and to the various manufacturers who cooperated by furnishing instruments and equipment.

[8]The Research Residence in Urbana, Ill., was built, furnished, and completely equipped specifically for research work in warm air heating by the *National Warm Air Heating and Air Conditioning Association* in December, 1924.

Oil Burner Institute Holds Meeting and Show

The Oilburner Institute, which succeeded the *American Oilburner Association* last July, held its first convention and annual meeting at Detroit, Mich., April 14-18, and the following officers were elected: *President*—W. F. Brannan, Baltimore, Md.; *Vice-Presidents*—M. F. Cotes, Lansing, Mich., M. A. Powers, Detroit, Mich., J. J. Donovan, Bloomfield, N. J., E. P. Bailey, Philadelphia, Pa., and Earl Marr, New York, N. Y.; *Executive Committee*—W. F. Brannan, W. J. Smith, Cleveland, O. (ex officio), J. J. Donovan, A. J. Fleischmann, Baltimore, Md., E. P. Bailey, J. H. O'Brien, New York, N. Y., F. H. Van Blarcom, Lynn, Mass., and M. F. Cotes; *Directors* (3 year term)—E. P. Bailey, C. H. Chalmers, Minneapolis, Minn., J. A. Berghoff, Fort Wayne, Ind., A. F. Reif, Buffalo, N. Y., R. S. Beale, Detroit, Mich., F. H. Dewey, Detroit, Mich., R. G. Whipple, Springfield, Mass., J. C. Johnson, Oakland, Calif., F. H. Van Blarcom, J. J. Nance, Dayton, O.; *Group Committees:—Domestic Burners*—J. J. Donovan, A. J. Fleischmann, J. J. Nance, R. G. Whipple, and C. N. Lockwood, Rock Island, Ill.; *Industrial Burners*—E. P. Bailey, J. H. O'Brien, and J. C. Johnson; *Distillate Burners*—M. F. Cotes and F. H. Van Blarcom.

At the meeting the outgoing president, W. J. Smith, and managing director, G. H. Porter, reiterated the Institute's program: To increase public and private interest in and demand for oilheating equipment; to encourage the use of high standards in manufacture and in assistance offered to dealers and distributors; to encourage uniform ordinances and constructive legislation; to extend cooperative activities with the American Petroleum Institute and other allied industries; to promote the use of the O.B.I. seal among members; and to enlist the aid of each member in getting new members.

Close cooperation with the American Petroleum Institute was reported and resulted last fall in a working agreement between both organizations which has proved to be effective particularly in ordinance work.

The chairman of the Uniform Ordinance Committee of O.B.I., Earl Marr, recently spent considerable time gaining support for the new law definitely assigning the duty of inspecting oil heating installations to New York City's Fire Department. At present the Institute is working against a bill recently introduced in Congress calling for a tax of ½c per gallon on fueloil used for heating.

A.S.H.&V.E.
SUMMER MEETING
JUNE-22-23-24

BE WISE OR YOU'LL BE OTHERWISE
USE YOUR BEAN A BIT
COME TO BUCK HILL FALLS THIS SUMMER
KEEP YOUR BRAIN AND BODY FIT.

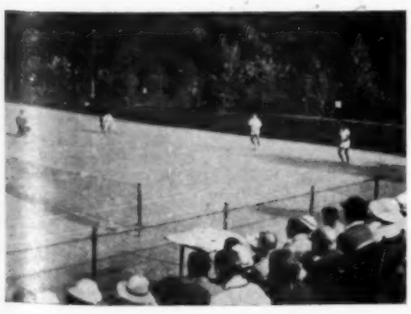
HAPPY DAYS AWAIT YOU
IN THE MOUNTAINS 'NEATH THE BLUE
LAUGHING IN A WORLD OF SUNSHINE
LIVING WITH THE 'CHOSEN FEW'.

FORTUNE SURELY SMILES UPON YOU
AS YOU RIDE AND GOLF AND PLAY
LIVING LIFE IN IT'S FULL MEASURE
LONGING FOR NO OTHER TREASURE
SATISFIED WITH JUST TO-DAY.

Joint Session at Buck Hill Falls

ANNOUNCEMENTS by the Program Committees of the *A.S.R.E.* and A.S.H.V.E. give the tentative programs for the meetings of the two Societies scheduled for June 22-24, and emphasize the fact that members of both organizations will enjoy a joint session in the auditorium of The Inn at Buck Hill Falls, June 23. Each Society will have three technical sessions. Details of the technical programs are given for the convenience of members who will attend the 1936 Semi-Annual Meeting of the A.S.H.V.E. at Buck Hill Falls and the 22nd Spring Meeting of the *A.S.R.E.* at Skytop.

Among the subjects of discussion are:—Measurement of Solar Radiation, Corrosion Studies in Steam Heating, Domestic Stoker Performance with Bituminous Coal,



Tennis at Buck Hill

Riding in the Poconos

The Auditorium

An Angler's Paradise

Heat Absorption of Sections in Domestic Boilers, Thermostat Tests, Heat Pump Applications, and Selection of Refrigerating Equipment for Air Conditioning.

For the information of members who are planning to attend the A.S.H.V.E. Semi-Annual Meeting, arrangements have been made for reduced round-trip railroad fares under the Identification Certificate Plan. These certificates with hotel reservation cards will be mailed to all members in the near future. For those who enjoy motoring, maps and road information will be supplied. Members living at some distance who prefer to travel by air will find it advisable to land at Newark and take the train from that point. A substantial saving can be effected if several people traveling by air use the scrip books which are available. A schedule of rates and the hours by air to Newark, N. J. airport are given in the accompanying table.

AIRPLANE FARES AND FLYING TIME

From	*To*	*One-Way Air Scrip Fare*	*Hours by Air*
Buffalo	Newark, N. J.* Airport	$18.66	1½
Chicago	" " "	40.76	4¼
Cincinnati	" " "	32.38	5
Cleveland	" " "	25.24	2¼
Denver	" " "	93.47	14¾
Detroit	" " "	29.49	3
Grand Rapids	" " "	38.21	7
Kansas City	" " "	59.46	8½
Los Angeles	" " "	136.00	16
Milwaukee	" " "	45.01	5½
Minneapolis	" " "	57.76	9¼
Oklahoma City	" " "	71.78	11¾
Pittsburgh	" " "	19.51	1⅔
San Francisco	" " "	136.00	16
St. Louis	" " "	48.41	8½
Seattle	" " "	136.00	16

*Motor car connections to Lackawanna R. R. Station for Cresco, Pa.

TRAIN SCHEDULES
(Eastern Standard Time)
(Lackawanna R. R.)

Buffalo, N. Y.			9:45 a.m.	10:25 p.m.
Cresco, Pa.			4:35 p.m.	5:14 p.m.
N. Y.	6:40 a.m.	10:00 a.m.	4.10 p.m.	6:00 p.m.
Cresco	10:44 a.m.	12:47 p.m.	7:02 p.m.	8:55 p.m.

(Pennsylvania and Lackawanna R. R.)

Philadelphia	7:00 a.m.	3:15 p.m. (Broad St. Sta.)	Pittsburgh	8:50 p.m.
Cresco	10:44 a.m.	7:02 p.m.	Cresco	11:24 a.m.

Members from Detroit and Cleveland may go by boat or train to Buffalo.

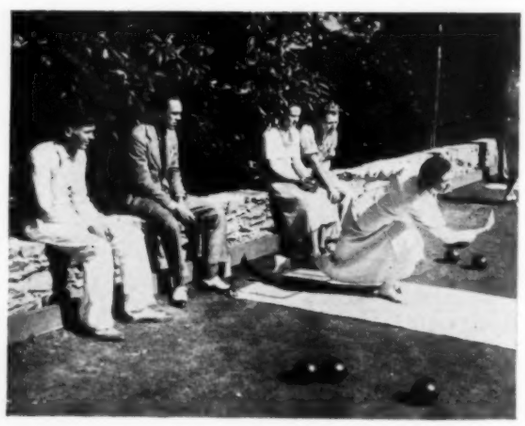
Through car service from various western and mid-western cities can be arranged by local Chapters cooperating on the selection of an official route.

Very attractive rates including room and meals at The Inn at Buck Hill Falls are available to members, and early reservations should be made by direct communication with The Inn on special cards. The schedule of American Plan rates for the meeting is given in the accompanying table, and permits a wide choice of accommodations.

Type of Room	Daily rate per person including meals
Double room with bath—twin beds—per person	$7.00, $7.50, $8.00
Double room, running water and toilet—twin beds—per person	6.50
Double room with lavatory—twin beds—per person	5.00
Single room with bath	8.50
Single room with running water and toilet	7.00
Single room with running water	5.00
Children (under ten) in room with parents	$3.00 Daily

All rates are American Plan and include room and meals. Acknowledgment of all reservations will be made by the Inn.

A Woodland Trail at Buck Hill



Lawn Bowling

Many members will recall the delightful meeting at Buck Hill Falls two years ago, and will want to return to the Poconos when the laurel and Rhododendrons are in bloom. The Inn offers many attractions to those attending the Semi-Annual Meeting, and provides a real vacation spot in a setting of natural beauty where there is an opportunity also to enjoy every type of outdoor recreation. A 27-hole golf course of championship character is just what the golf enthusiast requires in his battle to conquer Old Man "Par." For those who play tennis, 8 clay courts are ready for service. A new Olympic size swimming pool is being rushed to completion. Lawn bowling will attract its quota, and the scenic trails and paths for horseback riding and hiking offer enjoyable diversions to those who like the great outdoors.

Many mountain streams offer excellent trout fishing for the followers of Izaak Walton, and Governor Earle of Pennsylvania

COMMONWEALTH OF PENNSYLVANIA
GOVERNOR'S OFFICE
HARRISBURG

THE GOVERNOR

April 9, 1936

Mr. Harry H. Erickson,
Secretary, Philadelphia Chapter,
American Society of Heating and
Ventilating Engineers,
804 Architects Building,
Philadelphia, Pa.

Dear Mr. Erickson:

Thank you for your letter of April 2nd.

I am glad to advise you that the Board of Fish Commissioners reports that Buck Hill Creek was stocked on November 7th with a large truck load of very beautiful brook trout. The stream was also listed for a further stocking with some rainbow trout this spring, but unfortunately the recent floods carried away approximately a hundred thousand of the legal fish they expected to use in their spring stocking and this end of the work may be somewhat curtailed. However, I am assured that it will be taken care of as early as possible with another load of fish.

I hope that you will enjoy your spring fishing and that all the big ones will not get away.

Sincerely yours,

George H. Earle

writes that the streams will be well stocked for the pleasure of A.S.H.V.E. fishermen.

Members of the Philadelphia Chapter will be hosts for the Semi-Annual Meeting, and a program that should be especially attractive to the ladies has been planned. On Monday, June 22, at 10 a. m. there will be a motor trip, and after luncheon a swimming party will be enjoyed at the pool. A reception and tea will be held at 4 o'clock, and in the evening at 7:00 A.S.H.V.E. members and ladies will join with the *A.S.R.E.* group for a steak fry on Skytop Mountain.

On Tuesday morning the ladies have a choice of playing golf, horseback riding or a hiking party. At 1:30 a luncheon and bridge will be held for the ladies at the Tennis Club and in the evening all members and ladies will attend the Semi-Annual Banquet and Dance at The Inn.

On Wednesday, the special events for the ladies are bowling on the green in the morning, and an informal afternoon party.

When technical sessions are completed, the men will play on the Buck Hill Golf Course for the Philadelphia Chapter Cup on Monday afternoon at 1:30. On Tuesday afternoon, R. C. Bolsinger will try for the second leg on the Research Cup in the golf tournament to be held on the Buck Hill Course. On Wednesday, a kicker's handicap golf tournament is planned for those who enjoy the ancient Scotch game.

Fore

The Committee on Arrangements is hard at work planning a program for all who attend the Buck Hill Falls Meeting, June 22-24. Your hosts will be, R. C. Bolsinger, *General Chairman*, Committee on Arrangements; W. F. Smith, *Vice-Chairman*, Committee on Arrangements; M. F. Blankin, *Chairman*, Banquet Committee; J. H. Hucker, *Chairman*, Entertainment Committee; W. P. Culbert, *Chairman*, Golf Committee; H. G. Black, *Chairman*, Registration Committee; L. P. Hynes, *Chairman*, Finance Committee; M. C. Gillett, *Chairman*, Ladies Committee; and H. H. Erickson, *Chairman*, Publicity and Transportation Committee.

Tentative Program
A.S.H.V.E. SEMI-ANNUAL MEETING
The Inn, Buck Hill Falls, Pa.
June 22-23-24

Monday, June 22, 1936

8:30 a. m. Registration
9:30 a. m. Greeting
Technical Papers:
Corrosion Studies in Steam Heating Systems, by R. R. Seeber, F. A. Rohrman, and G. E. Smedberg
Performance of Under-Feed Domestic Stokers Burning Bituminous Coal, by T. G. Estep
Relative Absorption of the Various Sections of a Round Heating Boiler, by A. J. Johnson.
12:15 p. m. Get-together Luncheon

Tuesday, June 23, 1936

9:30 a. m. JOINT SESSION OF *A.S.R.E.* and A.S.H.V.E.
W. H. Carrier presiding
Theory and Practice of the Heat Pump, by C. W. Chamberlain
Application Factors Which Govern the Selection of Freon Refrigerating Equipment for Air Conditioning Service, by J. R. Hertzler
Water Supply as Affected by the Demand for Summer Air Conditioning, by D. C. Morrow

Wednesday, June 24, 1936

9:30 a. m. Technical Papers:
Development of Testing Apparatus for Thermostats, by D. D. Wile
Pyrheliometers and the Measurement of Total Solar Radiation, by L. A. Harding
Field Tests to Determine the Heat Requirements of Buildings, by F. E. Giesecke
Heat Requirements of the Grant Building, by F. C. Houghten

The 22nd Spring Meeting of the *A. S. R. E.* will be held at the Skytop Club, Skytop, Pa., and at the opening session on Monday, June 22, at 10:00 a. m., the topic of discussion will be Refrigeration of Foods. Papers will be presented on The Farmer's Egg Precooling Problem by J. E. Nicholas, Defrosting by S. Ruppricht, Application of Refrigeration to Brewery Stock Rooms by Walter Jones, and A Review of Fish Refrigeration Methods by D. B. Finn.

Members of the *A. S. R. E.* will hold a joint session with the A. S. H. V. E. on Tuesday morning, June 23, at The Inn, Buck Hill Falls, Pa.

The final session of the *A. S. R. E.* meeting will be on Wednesday at 10:00 a. m. and will be given over to a discussion of Thermal Problems, in the Domestic-Commercial Field. The program includes papers on Review of Practice in Domestic and Commercial Ice Refrigeration by C. F. Holske, Rational Theory of Surface Dehumidification by William Goodman, Shell Type Porcelain Enamel Refrigerator by F. L. Meacham and E. F. Schweller, and Infiltration Characteristics of Entrance Doors by A. M. Simpson.

Honorary Members

Reginald Pelham Bolton

Honorary Membership in the A.S.H.V.E. was bestowed upon Mr. Bolton with the following tribute: "In recognition of the eminent place occupied by Reginald Pelham Bolton, as a consulting engineer, author and historian."

Mr. Bolton's association with the A.S.H.V.E. dates from 1897 when he was elected a Member, so that he has an almost complete personal record of the Society's history. He served on the Board of Governors in 1901, as Second Vice-President in 1903, as First Vice-President and a member of the Board of Governors in 1905 and 1910, as President and chairman of the Board of Governors in 1911, and as a member of the Board of Governors from 1912-1913. In 1929 he was granted Life Membership by the Council of the Society.

Mr. Bolton was born in London, England, on October 5, 1856, and was educated in private schools. He served his apprenticeship with Powis, James & Co., Lambeth, England, from 1872-1876 and gained his early drafting experience in Colchester and London with Davey Paxman Co.

In 1879 Mr. Bolton came to America and engaged in consulting practice. Until 1892 he spent much of his time traveling in Europe on engineering work. He designed and erected mining machinery for sulphur mines in Caltanisetta, Sicily, and many steam plants on the island. He designed and superintended the building of marine engines for the Italian Government at Naples as well as various machine tools for their shipyards. He was also responsible for the following: the design and construction of several stern wheel steamers for Mexico and Spain; design and erection of electric light and other machinery in the Asturias; and the design and building of electric and steam hoisting machinery in England and Holland.

Since 1893 Mr. Bolton has been actively engaged in consulting engineering in New York City, where he is president of the R. P. Bolton Co. and president of the Electric Meter Corp. He has served as consulting engineer to the Department of Water Supply of New York, and among the engineering projects for which he has been responsible are the plant system of R. H. Macy & Co., Inc. and the New York Central Terminal.

Mr. Bolton is a member of many organizations including the *American Society of Civil Engineers, American Institute of Consulting Engineers, American Society of Mechanical Engineers, American Scenic and Historic Preservation Society,* and City History Club. He is a trustee of Dyckman Institute, former secretary of the *Washington Heights Taxpayers' Association,* an honorary life member of the *New York Historical Society,* and an associate member of the *Institution of Civil Engineers,* England, from which he received the Telford Gold Medal in 1902. His clubs are Lawyers and National Arts and his hobbies are history and travel.

Mr. Bolton's interest in engineering and history is apparent in his writings, which include the following: Motive Powers, 1895; The Assault of Mt. Washington, 1776, 1901; Elevator Service, 1908; The Indians of Washington Heights, 1909; Building for Profit, 1911, 15, 22; Power for Profit, 1915; An Expensive Experiment, 1913, 17; A Municipal Experiment, 1917; New York City in Indian Possession, 1920; Indian Paths in the Great Metropolis, 1922; Washington Heights—Its Eventful Past, 1924. He is the author of a number of papers which have been presented at meetings of the Society and which appear in its TRANSACTIONS.

L. P. Breckenridge

"In recognition of the eminent place occupied by Prof. L. P. Breckenridge as an engineer, a teacher, inventor and author," is the citation on the Honorary Membership Certificate conferred by the Society at the 42nd Annual Meeting.

Professor Breckenridge was born May 17, 1858, at Meriden, Conn. He served as apprentice for three years with H. B. Smith Co., Westfield, Mass., and was graduated from the Sheffield Scientific School of Yale University in 1881 with the degree of Ph.B. Later he received the honorary degree of M.A. from Yale in 1909, and the degree of doctor of engineering in 1910 from the University of Illinois. For eight years from 1882-91 he was instructor in mechanical engineering at Lehigh University. He was professor of mechanical engineering at Michigan Agricultural College from 1891-93, and professor of mechanical engineering from 1893-1909 and director of the Engineering Experiment Station from 1905-09 at the University of Illinois. His association as a member of the faculty of Yale began in 1909 when he became professor of mechanical engineering of the Sheffield Scientific School and continued until 1923 when he retired as Professor Emeritus of Mechanical Engineering.

In addition to his educational work Professor Breckenridge has done consulting engineering, particularly in connection with power, heating and ventilating. He has been engineer in charge of the Boiler Division, U. S. Geological Survey, and the fuel testing plant at St. Louis erected in 1904. He contrived and equipped dynamometer cars during 1897-99, and in 1901 he invented an automatic recording machine.

Professor Breckenridge served as chairman of the Advisory Board of the Super-power Survey from 1920-21 and was a member of the World Power Conference. He is a member of the *American Society of Mechanical Engineers* and was vice-president of the organization from 1907-09, a member of the *Society for the Promotion of Engineering Education* and the *Western Society of Engineers* of which he was vice-president 1905-06. His clubs include the Yale and Engineers Clubs of New York, and the Graduates Club of New Haven.

Professor Breckenridge joined the A. S. H. V. E. in 1920 and has contributed several papers to its TRANSACTIONS.

His hobbies are hunting ferns and orchids, travel, and photography—all of which he pursued in various parts of the U. S. and Europe. His recollections of his early days in the heating business give a vivid picture of the progress of the art in a period of nearly 70 years.

My dear Mr. Hutchinson:

You know they say "Tell me the playthings of the child and I will tell you his probable career."

1868—Well here I am ten years old and living at Meriden, Conn., where I was born. My father is working in a Meriden factory—but he is spending his evenings at home in the kitchen. I am watching him at work making some funny little wooden things which he calls "patterns

and core boxes." One night he brings home some sand and mixes it with flour and bakes it in the oven. A little later he brings home a cylindrical hollow casting—it is closed at one end but open and threaded at the other. Inside is a loosely fitting casting holding at each end a bowed brass strip in it—by applying heat to the brass which he did by putting it all into boiling water he showed me how it would expand enough to move a small brass spindle—and thus was born the "Breckenridge Automatic Air Valve," my father's first patent.

1869—M. P. Breckenridge, my father, moves to Westfield, Mass. and is made superintendent of the H. B. Smith Company, manufacturers of heating apparatus. Their factory was then generally known as "The Foundry" and taking one's friends down to see them "pour off" was one of the sights.

1870-1876—I go to school but work part of my vacations down at "The Foundry."

1876—I graduated from the Westfield High School and expected to go to college, but my father said: "No you better go to work and learn a trade, then you won't starve to death"—I went to work for the H. B. Smith Company. At the end of 2½ years I was earning more money than any workman at the foundry, and one day father said, "Do you suppose you could get into Yale?" I got in and graduated in Mechanical Engineering from the Sheffield Scientific School in 1881. There were 45 in the class. I was one of seven allowed to read extracts from my Thesis ("Methods of Measuring Motive Power") on the platform at Commencement. What an event—I can see the flowers—I can hear the applause (all from relatives, of course). The royalties on the "Air Valve" had paid most of my expenses through college—and so 55 years later I am elected an Honorary Member of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS—I appreciate the Honor—I am profoundly grateful.

—L. P. Breckenridge.

P. S.—Again 1876-1878—Recollections and impressions of my work shop years. Just a word now and then must suffice. Before beginning work I went to the "Centennial Exposition of 1876"—the first time I ever went away from home alone—My pay the first year was 90 cents a day for 10 hours. I was at the shop with my overalls on and ready for work when the whistle blew at 7:00 (Our home was 14 minutes away from the factory—we lived on a corner lot 4x8 rods with sidewalks that must be cleaned of snow before breakfast—and I was an only child.) My work was quite varied—sweep up—oil the line shafting once a week—clean castings—help load radiators—make anchors and chaplets—run errands, lots of 'em—no telephones then—no bicycles—run the tumbling barrels—help pickle castings—take lathe and planer tools down to Mr. Dewey, the blacksmith—cut paper and rubber gaskets for the flanges of the Gold Pin Radiators and the "long bolt" Gold Boilers—also the long bolts for the hot air "Hygean Heaters." These Boilers and Heaters lived in brick houses down cellar in those days. The radiators and boilers soon had short bolts and then nipple connections.

I knew well the early direct radiators that followed pipe coil such as—the "Gold bedquilts" of wrought iron riveted together—The Whittier with flat fins—The Nason of pipes screwed into a cast iron base—"The Reed" cast iron sections pressed into cast iron bases—I cut the copper rings for the joints—The "Union Radiator" cast iron sections pressed together—I made the drawings for this radiator—I believe this was the first cast iron sectional hot water radiator on the market.

The "Mills" boiler—Jack Ford made these castings in the foundry—I took "anchors" to Jack every morning—I liked Jack—he taught me the foundry business. I knew John H. Mills. I made drawings for him back in '79 and '80. For ventilation we put a big slow turning fan in the attic of the Court House at Springfield, Mass., driven by a 30 "Tuerk" water motor. No electric motors then. I always figured the direct radiation for rooms by the old Mills Rule—

$$\frac{C}{200} + \frac{O.W.}{20} + \frac{G}{2}$$

equals Sq Ft Radiation—Mills would then go over the building with me, take a look into the rooms and mark down with chalk what he guessed would be about right—say, he was a good guesser.

Why did I mislead you by saying I'd write "a few words"—Well: as the telegram says "STOP."

Sincerely,

L. P. BRECKENRIDGE.

April 21, 1936
"The Brackens"
North Ferrisburg, Vermont

New York Engineers Hold Joint Symposium on Air Conditioning

On April 2, 1936, the New York Chapter of the Society in cooperation with the *American Society of Refrigerating Engineers,* New York Chapter of *American Institute of Architects,* Management Division of *Real Estate Board,* and *New York Railroad Club* participated in a symposium on air conditioning sponsored by the *American Society of Mechanical Engineers* in the Engineering Societies' Building, 29 West 39th St., at which approximately 600 members of these technical societies and guests were present.

W. L. Fleisher, consulting engineer of New York, and member of the A. S. H. V. E. Council, acted as presiding chairman for the meeting, and in addition, discussed Modern Trends in Air Conditioning. It was his opinion that the modern trends in air conditioning for the future would be to equipment which was capable of producing increased air movements, higher relative humidities, additional outside air, and increased cleaning effects of the outside air. He explained that the type of installation provided in large moving picture theaters is in most cases out of the price range of the average person, but these comfort conditions could be produced in public buildings because the cost is widely distributed, each individual paying on an $18 per capita investment. If the individual should demand in his own home, the equivalent of what he receives in a moving picture theater, he would be paying from $250 to $500 for the same investment in equipment.

A. E. Stacey, Jr., vice-president of the Buensod-Stacey Corp., New York City, gave a paper on Central Station Versus Unit Systems of Air Conditioning. In summarizing the various design features, he stated that as far as the functional parts of an air conditioning system were concerned both the central and unit systems were complete. In the design of the central station equipment, the emphasis is placed on the selection and arrangement of equipment giving the best overall efficiency to fulfill a definite set of known conditions, while the emphasis of design for unit equipment must be more general and fulfill the average demand of many conditions of a particular class of installation. Mr. Stacey stated that it was his opinion that the unit system is suitable for installations up to certain sizes, and for applications greater than these, the central station plant would result in an economy of operation and upkeep.

The Architect Views Air Conditioning was the title of a paper presented by Francis Keally, member of the *American Institute of Architects.* He discussed the advantages of additional wall space and the elimination of fabric fading in connection with sunlight exposure when air conditioning was available for windowless department store design. In the design of libraries, it was pointed out that the complete air conditioning of a structure of this kind makes possible the proper control of humidity to prevent the cracking and drying of glue in the book covers, sulphur dioxide is eliminated, thus preventing the pages from turning yellow, and of course the dust and dirt which is removed by the complete equipment is an important consideration. Finally he urged the cooperation of the proper coordination between the architect and engineer in connection with architectural design so that the aesthetics of room interiors may be preserved while at the same time incorporating efficient and desirable ventilating and air conditioning layouts. As an architect he felt strongly that air conditioning is going to play an important role in all future architectural problems and that due to the fact that the public demands it today, it is necessary for the architects to keep informed on all important new and outstanding features of the air conditioning industry.

John Everetts, Jr., secretary-treasurer of the Air and Refrig-

eration Corporation of New York, discussed cooling methods and in introducing his remarks he mentioned that the most important advances in the past 13 years in the air conditioning industry were not in the methods or equipment used, but in the knowledge of the requirements and conditions best suited for comfort. He mentioned that new methods of air conditioning, new design and improvement of equipment have followed research and development of comfort standards so carefully and laboriously worked out by the A.S.H.V.E. Research Laboratory of the Society. Mr. Everetts discussed in detail the following methods of air conditioning: (1) evaporative cooling, (2) cooling with refrigeration effect, and (3) dehumidification air cooling, and indicated the principal equipment which is essential for each system.

Weather in Relation to Air Conditioning was discussed by Dr. J. H. Kimball, head of the New York U. S. Weather Bureau, and also Mr. C. F. Holske of the American Ice Co. gave a paper entitled, The Place of Ice in Air Conditioning.

The speakers as honored guests and 80 members of the *A.S.R.E.* and A.S.H.V.E. enjoyed a pre-meeting dinner at the Building Trades Club, 2 Park Ave., before adjourning to the Engineering Societies' Building.

Contractors to Meet in Philadelphia

A three-day program has been planned for the 47th Annual Convention of the *Heating, Piping and Air Conditioning Contractors National Association* at Philadelphia, Pa., May 25, 26, 27. The Bellevue-Stratford Hotel will be headquarters, where all sessions are to take place.

At the opening session, 9:00 a. m., Monday, H. G. Black, president of the local association, will welcome the members and guests to Philadelphia and reports of committees will be presented. The afternoon meeting, beginning at 2:00 p. m., will be devoted to a discussion of Sales Promotion.

At the Tuesday morning technical session, W. L. Fleisher, New York, N. Y., will be one of the speakers and his subject is Air Conditioning from a Promotional Angle. Golf, sightseeing, and a dinner dance are planned for the remainder of the day and evening.

Additional committee reports as well as several addresses will be given Wednesday, May 27, at 9:00 a. m., and in the afternoon the election of officers will be held.

Comfort Standards for Summer Air Conditioning Subject of Cleveland Chapter's Meeting

March 17, 1936. Seventy-five members and guests attended the regular meeting of the Cleveland Chapter at the Cleveland Club. The open meeting was preceded by a dinner and business meeting at which 19 members were present with F. C. Houghten, director of the A.S.H.V.E. Research Laboratory, Pittsburgh, Pa., who was the guest speaker of the evening.

A communication from A. V. Hutchinson was read advising of an amendment to the Society's Constitution and By-Laws, relating to the transfer of Student Members to Junior Membership and calling attention to the schedule of dues rates for 1936.

Secy. Philip Cohen also read a report of the Council meeting held at Chicago.

New business was taken up and a motion was made by M. F. Rather, seconded by F. R. Dickenson and passed, to appoint a committee to revise the Chapter Constitution.

It was reported that the following new members have been elected to Chapter membership since the January meeting: C. E. Hansen, A. G. Allen, Arthur Bennekamper, G. F. Metzdorf, N. E. Dailey, V. T. Kartorie and A. C. Kuehnert.

L. T. Avery, chairman of the Program Committee, solicited written suggestions from the audience on a subject for the April meeting and Residential Air Conditioning was selected.

Treas. H. M. Nobis reported on Chapter finances and announced that the treasury showed a balance of $538.13 as of March 16, 1936.

The business meeting adjourned at 8:10 p. m.

Mr. Houghten was introduced and spoke on Comfort Standards for Summer Air Conditioning. He elaborated on the paper presented at the Society's meeting in Chicago and illustrated his talk with slides, showing detailed results of tests upon which his recommendations were based.

Following Mr. Houghten's address, W. R. Rhoton emphasized the effects of air motion and the lack of attention which has been paid to this important item.

Following a question and answer period, another successful meeting of the Cleveland Chapter was concluded.

Illinois Chapter Hears Report on Results of Public Works Program

April 13, 1936. Pres. J. H. Milliken called the April meeting of the Illinois Chapter to order at 7:50 p. m., with an attendance of 96, and the minutes of the previous meeting were read by Secy. L. S. Ries and accepted.

An invitation from Prof. M. K. Fahnestock to members of the Illinois Chapter to attend the 1936 Conference on Air Conditioning at the University of Illinois, May 4 and 5, was read.

Two new chapter members were welcomed—J. R. Boyle and J. S. Whittington.

The members were reminded by President Milliken that this year the annual meeting of the chapter was to take place in May.

S. R. Lewis introduced Col. W. A. Danielson, Washington, D. C., chairman of the A.S.H.V.E. Committee on Research. Colonel Danielson responded briefly, stating that he was interested in having the research activities of the Society as comprehensive as possible, and he requested members to write him of their suggestions.

President Milliken stated that through the efforts of John Howatt the services of C. H. Bauer had been secured as speaker of the evening. James McCauley introduced Mr. Bauer and told of his fitness for his connection with the Public Works Program. Mr. Bauer then spoke on the subject of P.W.A. In Action.

The speaker stated that in 1929 the construction in the United States was $12,000,000,000, three-quarters of which was being done by private industries. In 1933, total construction in the United States was $3,000,000,000, one-half of which was being done by private industries. This slowing up of construction had the effect of closing many architect's and engineer's offices and discontinuing the work of thousands of building trades workmen, mechanics and specialists. The P.W.A. was organized to perform in a construction program that would be of lasting benefit to the nation. It has provided 10,100,000 men months of employment. Allotments have been made to every state in the union and almost every county in every state. The P.W.A. projects are financed by a grant of 45 per cent of the total cost by the federal government, with the community financing 55 per cent. Of all P.W.A. money 60 per cent goes into the production of materials for construction projects. In Illinois $155,000,000 is being spent. All P.W.A. projects are of a self-liquidating type. Each project is carefully scrutinized and rated from the social and economic standpoint. Mr. Bauer stated that P.W.A. projects have benefited:

(1) Architects and engineers throughout Illinois.

(2) Building Contractors: He pointed out that the contracts are made with the municipalities. Certain requirements by the P.W.A. must be met before they can be released.

(3) Industries: He stated that 60 per cent of the $1,224,000,000 goes for materials, which helps all industry.

(4) The Community: The Community benefits in receiving desirable permanent assets, such as schools, bridges, water works, etc.

(5) Labor: Labor has been returned to employment at a fair wage level on a thirty hour per week schedule. Local people in the community have been given preference in employment wherever it was possible to find the necessary kind of labor in the community. Convict labor has not been allowed by the P.W.A. It has not discriminated for or against unions.

(6) The Municipal Bond Market was benefited by the purchase of $300,000,000 of this collateral. This made it possible for local communities to raise the necessary funds to participate in P.W.A. projects.

Mr. Bauer remarked that at present in Illinois there are 11,000 men under employment and this is to be increased at the rate of 2,500 per week. The peak in employment will probably be over 30,000 in this state. Mr. Bauer's staff is divided into the following sections: (1) Engineering Section, (2) Legal Section, (3) Financial Section, (4) Accounting Section, (5) Investigation Division.

After this paper was completed a very lively discussion followed in which Mr. Bauer explained items of interest that had not been brought out in the paper. Many of the members of the chapter complimented Mr. Bauer on the type of organization he headed, and mentioned that they had found his organization to be entirely reliable and fair. Among those who participated in this discussion were: Messrs. Howatt, Danielson, Hart, Finan, Thomas, Teisen, Mittendorf, Brooks, and Aeberly.

President Milliken then requested Mr. Bauer to introduce the members of his staff who were attending and he presented Messrs. Farley, Ferguson, Bates, and Logan.

The meeting adjourned at 10:10 p. m.

Winnipeg Hydro Electric System Described at Manitoba Chapter Meeting

March 26, 1936. Twenty-one members and guests were present at the meeting of the Manitoba Chapter held at the Fort Garry Hotel, Winnipeg. Secy. C. H. Turland reports that after an enjoyable dinner the regular business was disposed of, the Nominating Committee's report being adopted unanimously.

Pres. J. B. Steele then introduced the guest speaker of the evening, J. W. Sanger, chief engineer of the Winnnipeg Hydro Electric System, who chose as his subject Hydro in Winnipeg, which proved a very interesting one. Afterwards, Mr. Sanger answered several questions and H. R. Eade moved that he be given a vote of thanks.

Harvard's Heating System, Dust Collection, Design of Exhaust Systems, Subjects of Massachusetts Chapter Meetings

March 9, 1936. The Massachusetts Chapter of the A.S.H.V.E. met at the Faculty Club of the Harvard Business School, Boston, and D. S. Boyden, 1st Vice-President of the Society, reported on the Chicago meeting and the Heating and Ventilating Exposition.

A motion was unanimously passed that the Massachusetts Chapter extend an invitation to the A.S.H.V.E. for the Summer Meeting in 1937.

Philip Drinker, chairman of the Papers and Meetings Committee, introduced G. K. Sauerwein, superintendent of the Engineering Division of Harvard University, who explained the system of district heating at the University.

Mr. Sauerwein mentioned that Harvard is celebrating its 300th anniversary this year and some of the buildings are over 200 years old. The growth of district heating has, therefore, been gradual, starting in 1914 when steam was purchased from the Boston Elevated Railway. Through gradual increase this plant became overloaded and, since the land was valuable was purchased and destroyed. Plans had progressed for a new power plant to the point of contracting for boilers when an advantageous arrangement was made with the local electric company to purchase steam from a plant which had become obsolete and power was secured from the Boston Edison Co. Steam has been piped mainly in tunnels, from this plant, to most of the major building groups.

All types of heating systems are included but most of the new structures use closed hot water systems with converters at the buildings. Mr. Sauerwein stated that experience had indicated that this type of system was simplest and easiest to control and maintenance was reduced to a minimum. Due to the use of high temperature made possible by closed systems, standard size radiators have been installed.

In response to questions Mr. Sauerwein stated that very little trouble with freezing had been noticed as on nights below 15 deg some heat is kept on continuously.

Control is sometimes automatic, but in most cases operation is by hand control at a main valve, which is opened according to an outside temperature chart prepared for each building. Steam is measured by flow meters at the station and condensate meters at the buildings. The system contains a total of 2½ miles of tunnels and the pressure drop is from 100 lb to 25 lb at the most distant point. The maximum load is 200,000 lb steam per hour and the yearly consumption is 500,000,000 lb of which 90 per cent of the condensate is returned.

After answering numerous questions, Mr. Sauerwein escorted the members on an inspection tour of the equipment.

January 13, 1936. At a meeting held at the Harvard School of Public Health, Boston, a paper on Dust Collection was presented by Philip Drinker, a member of the faculty.

Professor Drinker stated that in most cases dust is removed because it is inimical to public health, but occasionally it is collected for its monetary value although no market has yet been developed for dust which will pass through a 325 fine mesh screen.

According to the speaker, a certain momentum is necessary to create proper impingement on viscous filters which in air cleaning varies from 10 to 300 fpm. It was mentioned that tobacco smoke will pass nearly all viscous filters and that resistance on this type runs from 1/16 in. to 1 in., the latter being too high for heating and ventilating equipment. Velocities on dust collection filters are low, running from ½ to 6 fpm with a resistance varying from ¼ to 1½ in. static pressure.

Professor Drinker stated that dust traps, cyclones, etc. are inefficient on dust below 200 mesh size. Cloth filters are used for zinc oxide particles less than 1 micron in size, but it was noted that 36 layers did not prevent the passage of tobacco smoke. This smoke, however, can be reduced by the use of an air mat and continuous recirculation will eventually eliminate the major portion. A filter cloth treated with filler material can be increased from 30 per cent to 35 per cent in efficiency, and this treatment is frequently applied to gas masks.

Professor Drinker said that percentages of dust collection efficiency are not in themselves conclusive as consideration must be given to the type of material they will filter, and examples were presented to illustrate this point.

A discussion followed by T. F. Hatch, Department of Industrial Hygiene, Harvard School of Public Health, on the Design of Exhaust Systems.

Mr. Hatch stated that exhaust hoods are of greatest importance as is the minimum static suction at the base of the hose. He mentioned that in Illinois the static suction method of calculation has been replaced by the velocity pressure method, which Wisconsin is also considering.

Continuing the discussion, Mr. Hatch said that the first important step in designing an exhaust system is to reduce air motion and to design hoods which will overcome the air motion created by grinding wheels, pistons, other machinery, etc. He expressed the opinion that the hood itself should be designed to create the least possible air motion, though since the efficiency is small, this can not be completely accomplished.

Michigan Chapter Hears Talks on Sales Tax and Manufacture and Application of Dry Ice

April 20, 1936. Approximately 40 members and guests were present for the dinner and meeting of the Michigan Chapter which was held at the Wardell Hotel, Detroit. G. D. Winans presided in the absence of Vice-Pres. R. K. Milward.

A detailed treasurer's report was given by F. J. Feely and Mr. Winans explained the formation of the new *Engineering Society of Detroit* and gave complete details as to how the new organization will function.

The first speaker of the evening was E. T. Conlon, assistant attorney general of the State of Michigan, who gave an interesting talk on the Michigan State Sales Tax and the disbursement of the tax money.

Arthur Schubring, research and development engineer, Michigan Alkali Co., was the second speaker and discussed the Manufacture and Application of Dry Ice.

Secy. W. F. Arnoldy reports that, there being no further business, the meeting adjourned at 10:30 p. m.

Dust Problem in Air Conditioning Discussed at Minnesota Chapter Meeting

March 9, 1936. The Minnesota Chapter held its regular meeting at the Minnesota Union, University of Minnesota. Dinner was served at 6:30 p. m., after which the meeting was called to order by Pres. C. E. Gausman, with an attendance of 38 members and guests. The minutes of the previous meeting were read and amended at the suggestion of Albert Buenger.

Prof. F. B. Rowley, chairman of the committee appointed to investigate Student Membership, reported and it was decided to forward a letter to headquarters office calling attention to the views of the Minnesota Chapter in regard to increasing the dues of Student Members in the Society.

Professor Rowley gave the principal talk of the evening on The Dust Problem in Air Conditioning, which was constructive and interesting. Starting with the definition of standard dust, as it applies to the A.S.H.V.E. Standard Code for Testing and Rating Air Cleaning Devices Used in General Ventilation Work, Professor Rowley considered the subjects: properties of dust, method of counting, and showed by means of a projector many different kinds of dust as they appear under a microscope.

The speaker stated that the important properties of dust are weight, size, and number of particles per cubic foot. Dust, as defined by Professor Rowley, is minute particles in the air, ranging from ¼ in. in diameter to a few microns. The quantity of dust per cubic foot ranges from 50,000 particles in reasonably clean air to a million in dirty air. Usually, dust detrimental to health is the small particles, 6 microns or less, which goes into the lungs, or pollen which collects in the upper nasal tract.

There are several methods of counting dust, according to Professor Rowley, some of which are as follows: impinging dust on a viscous liquid; filtering through water; electrical precipitation; and filtering through a sugar solution. These methods all have advantages and disadvantages and Professor Rowley expressed his belief that the most satisfactory method is that of impinging dust on a viscous liquid, providing an accurate method is devised for doing this. He showed a dust counter, developed at the University of Minnesota, in which the slide holding the viscous liquid moves across the path of the expelled air stream at a rate proportional to the speed of the plunger. With this apparatus a higher count is generally obtained than with other devices previously used, indicating greater efficiency.

Professor Rowley mentioned that, strange as it may seem, dust in air serves a very important function. Dust particles form the nucleus for raindrops, so that without dust there would be no precipitation, although atmospheric conditions might otherwise be favorable.

President Larson Guest of Oklahoma City Chapter; Speaks on Heating

April 3, 1936. Prof. G. L. Larson, Madison, Wis., president of the A.S.H.V.E., was the honored guest and speaker at the April meeting of the Oklahoma City Chapter, held in the Commerce Exchange Building. The assembly was called to order by Chapter Pres. F. X. Loeffler at 8:00 p. m. with 30 members and guests present.

President Loeffler reported that the Standards Committee would begin work the following week. This committee, with S. L. Rolland as chairman, was made up of one representative of each of the refrigeration manufacturers represented locally, B. R. Miller and R. W. Schulte.

President Larson was introduced by Mr. Loeffler and paid tribute to the outstanding work of the members of THE GUIDE Publication Committee in providing a volume which is more complete than any textbook and is constantly brought up to date. He also urged attendance at the Semi-Annual Meeting of the Society to be held in Buck Hill Falls, Pa., during June and the Annual Meeting to be held in St. Louis, Mo., in January, 1937. President Larson spoke of the growth of the Society, predicting a membership of 2,500 by the close of the year.

Professor Larson then gave a very instructive lecture on The Economics of Good Construction as Related to Residence Heating. This was followed by a discussion which brought out many interesting facts.

President Loeffler expressed the Chapter's appreciation of President Larson's presentation of the subject and he told the members of the Council's recent ruling discontinuing Limited Chapter Membership. There was some discussion of how to manage the attendance at Chapter meetings of non-members, but no definite decision was reached and the chairman of the Membership Committee was asked to make a recommendation at a later meeting.

Prof. E. F. Dawson announced the May 11 meeting at the University of Oklahoma and it was voted to leave the decision in regard to holding a June meeting to the Board of Governors.

Secy. E. W. Gray reports that it was suggested by I. G. Howlett that the new Municipal Auditorium would provide the Chapter with a reason to begin working for an Annual Meeting of the Society and the meeting adjourned at 10:00 p. m.

Ontario Chapter Hears Discussion of Sound in Relation to Air Conditioning

April 6, 1936. A dinner and meeting of Ontario Chapter was held at the Royal York Hotel, Toronto, with 55 members and guests attending.

Following dinner an announcement was made by the Nominating Committee of officers nominated for the coming year, as follows:

President—Thomas McDonald.
Vice-President—G. A. Playfair.
Secretary—H. R. Roth.
Board of Governors—H. B. Jenney, H. D. Henion, and J. W. O'Neill.

Mr. McDonald introduced the principal speaker of the evening, E. L. Anderson, who gave an illustrated lecture on Sound in Relation to Air Conditioning. Following Mr. Anderson's address there was discussion on various phases of the subject and E. H. Gurney extended a vote of thanks to the speaker for his splendid talk.

Heating and Ventilating of Airplanes Subject of Pacific Northwest Chapter's Meeting

March 24, 1936. Dinner was served at 6:30 p. m. and the business meeting of the Pacific Northwest Chapter was called

to order at 7:50 p. m. in the Hungerford Hotel, Seattle, Wash., with 33 members and guests present.

S. D. Peterson reported on his canvass of men in Vancouver, B. C., who might be interested in forming a Chapter there. An invitation was extended through R. E. Johnston to all those who were interested to attend the April meeting as guests of the Pacific Northwest Chapter. A. L. Pollard was appointed to meet the delegation and arrange for their entertainment.

Lyle Wood, project engineer, Boeing Aircraft Co., was the principal speaker of the evening. His subject was The Heating and Ventilating of Airplanes, exemplified by the air transport company with which he is connected. The subject was very ably presented and illustrated with blackboard sketches. The problems encountered in maintaining the proper air delivery and temperatures inside the cabin when the outside temperatures vary as much as 60 deg in 10 min require extensive research. The hot air, liquid heaters, steam and auxiliary electric heaters were each explained and their advantages and disadvantages were outlined.

M. N. Musgrave then spoke on temperature control instruments for airplanes.

Secy. D. C. Griffin has reported that the meeting adjourned at 9:35 p. m.

Economic Influences of Air Conditioning Outlined to Philadelphia Chapter

April 9, 1936. The regular meeting of Philadelphia Chapter was held at the Engineers Club and, after a delightful dinner, the meeting was called to order at 8:00 p. m. with Pres. J. H. Hucker presiding.

President Hucker asked W. F. Smith to introduce the speaker, H. H. Mather of the Philadelphia Electric Co., who read a paper entitled, Economic Influences Affecting the Future of Air Conditioning. Mr. Mather outlined the part air conditioning has played in industry and gave his views on the future prospects of air conditioning in the commercial field. The paper was well presented and received with approval. The discussion, which followed, brought comments from J. D. Cassell, F. D. Mensing, P. L. Davidson, Morris Sheffler, W. F. Smith, and R. C. Bolsinger.

The business meeting was called to order at 9:00 p. m. with the reading of the minutes of the previous meeting, which were approved.

L. P. Hynes read the Treasurer's report, which was also accepted.

R. F. Hunger, chairman of the Auditing Committee, consisting of L. E. Moody and M. F. Blankin, reported that the books had been audited and found correct.

Mr. Hynes, who is chapter representative for the Affiliated Societies of the Engineers Club, told of their activities in connection with helping to place unemployed engineers, etc.

The importance of attending the A.S.H.V.E. Semi-Annual Meeting at Buck Hill Falls, Pa., June 22-24, was emphasized by Secy. H. H. Erickson.

President Hucker outlined the procedure for the election of Chapter officers. Mr. Blankin suggested that the nominations as recommended by the Nominating Committee be accepted and moved that nominations be closed. This action was seconded by Mr. Sheffler. Comment on the action of the Nominating Committee, regarding the selection of the nominees was made by F. D. Mensing and H. G. Black, after which the President called for the vote, which was unanimous, instructing the Secretary to cast the ballot for the election of the following:

President—W. F. Smith.
Vice-President—L. P. Hynes.
Secretary—H. H. Erickson.
Treasurer—R. F. Hunger
Board of Governors—J. H. Hucker, S. E. Plewes, and C. B. Eastman.

The Secretary cast the ballot as instructed.

Mr. Hucker outlined the high points of his administration and requested Mr. Bolsinger to conduct the newly elected officers to the platform where Mr. Hucker turned the gavel over to the new president, Mr. Smith.

Mr. Blankin then spoke of the untiring efforts of Past President Hucker in behalf of the Chapter and presented to him a set of wood golf clubs as a mark of appreciation of the membership.

After a response of thanks by Mr. Hucker, President Smith adjourned the meeting at 10:45 p. m.

Housing Research, Determining Degree Days Discussed by Pittsburgh Chapter

April 13, 1936. Pres. R. J. J. Tennant called the meeting of the Pittsburgh Chapter to order at 8:00 p. m. in the Auditorium of the U. S. Bureau of Mines, and the minutes of the March meeting were approved as read. Twenty-nine members and guests were present.

Treas. J. F. Collins, Jr. reported receipts for the past month and also told the chapter that he was unable to deposit the meeting funds as instructed at the March meeting because the Mellon National Bank found that it could not legally accept such deposits.

It was moved by F. A. Gunther, seconded by P. A. Edwards, and passed that the Board of Governors be instructed to deposit $700 of the meeting funds in such manner as deemed to be for the best interests of the Chapter.

A report of the Air Conditioning Code Committee was given by G. S. McEllroy, chairman, who stated that his committee had received copies of proposed codes from other interested organizations and was studying them.

Secy. T. F. Rockwell read a letter from headquarters office, requesting that the Chapter study THE GUIDE 1936 with the idea of suggesting ways to improve the 1937 edition.

It was moved by Mr. Collins, seconded by Mr. Gunther, and passed that the proposed amendment to Section 2 of the By-Laws be adopted.

F. C. McIntosh was appointed as alternate to the Nominating Committee from the Pittsburgh Chapter by President Tennant.

Mr. Rockwell, chairman of the Current Events Committee, introduced D. C. Kellner, Senior student from Carnegie Institute of Technology. Mr. Kellner abstracted several articles in current architectural magazines on the Purdue University Housing Investigation.

The remainder of the program was taken up by the Committee for the Study of the Degree Day. Chairman Gunther read a report which clearly indicated that much labor had been expended upon this problem.

Mr. Gunther first discussed the methods of computing the so-called normal degree days for the heating season and cited the desirability of standardizing a method of determining this quantity for a locality. He also presented a number of charts which showed the relation between fuel consumption and the several normal degree days now in existence.

The Committee also recommended the adoption of a utilization factor to increase the accuracy of estimates of fuel consumption which are apt to be in error because of psychological factors.

Following Mr. Gunther, J. E. McLean, of the Dept. of Buildings and Grounds of the University of Pittsburgh, discussed the paper at some length. While admitting that the present method of determining normal degree days is in error, he questioned whether the refinement in method would be justified by the time and expense necessary to conform to the committee's recommendation on a nationwide scale. Mr. McLean also presented a number of slides in support of his belief.

Mr. Collins, a member of the committee, in a brief discussion listed the inaccuracies existing in the present method of determining normal degree days and also suggested that base temperatures other than 65 deg be used for special buildings such as churches, parking garages, and warehouses.

Following further discussion from the floor, the Chapter asked that the committee abstract its report together with its recommendations in such form that copies could be mailed to the members for study and it was planned to take action on the report at the May meeting.

The meeting adjourned at 10:45 p. m.

St. Louis Chapter Hears Address on Use of Silica Gel in Air Conditioning

March 6, 1936. Pres. C. R. Davis called the meeting to order at 7:35 p. m. with 17 members and 14 guests in attendance at Garavelli's Restaurant. The minutes of the previous meeting were read and declared approved.

President Davis reported that preliminary steps had been taken to organize for the next Annual Meeting of the A.S.H.V.E. to be held in St. Louis during January 1937 and that the Chapter's work would require all members to put their shoulders to the wheel.

Secy. R. J. Tenkonohy read correspondence from A. V. Hutchinson regarding an amendment to the Constitution relating to Student Members and membership dues in the Society.

Treas. E. E. Carlson reported a balance on hand as of March 6, 1936 of $431.44.

President Davis stated that he felt it desirable to increase efforts toward enlarging membership and that he had arranged a team for each of the committee members.

It was reported by D. J. Fagin, of the Program Committee, that Prof. G. L. Larson, president of the A.S.H.V.E., was to be the speaker at the April meeting.

E. E. Carlson of the Entertainment Committee announced that a social evening was being considered for the June meeting.

In accordance with an amendment to the Chapter's Constitution, President Davis asked for nominations for three members of the Nominating Committee. Properly proposed and seconded were P. W. Sodemann, J. W. Cooper, and C. E. Hartwein, who were elected. Then President Davis appointed two members, J. M. Foster and L. W. Moon, and declared Mr. Sodemann the chairman of the Nominating Committee.

Mr. Fagin took charge of the meeting for the program and presented J. C. Patterson, Bryant Heater Co., Cleveland, Ohio, who gave an address on Silica Gel and Its Application to Air Conditioning. Owing to conflicting engagements, W. E. Stark, who had expected to be present as speaker, could not attend. Mr. Patterson stated that he wished to present the difference in methods of accomplishing air conditioning, and stressed a direct method of dehumidification irrespective of cooling, as accomplished with silica gel. The development of silica gel from its use in gas masks was effectively traced. Its application in air conditioning was shown diagrammatically by slides; and in principle, pictorially, by latest units and comfort cooling installations. Mr. Patterson answered many questions presented by the audience.

According to the report of Secretary Tenkonohy the 41 members and guests attending arose as one in a vote of thanks to Mr. Patterson.

Mr. Fagin returned the meeting to President Davis, who declared adjournment at 9:30 p. m.

Economics of Good Residence Construction and Air Conditioning Code Subjects of Southern California Chapter Meetings

April 7, 1936. The April meeting of the Southern California Chapter was held at the Rosslyn Hotel on the occasion of the visit of Prof. G. L. Larson, Madison, Wis., president of the A.S.H.V.E. Dinner was served at 6:30 p. m. and A. H. Simonds presided at the meeting which was attended by 42 members and guests.

Earlier in the day President Larson was met on his arrival by a committee from the Chapter consisting of O. W. Ott, E. H. Kendall, A. H. Simonds, H. H. Bullock, and A. G. Orear. The party motored to the hotel for luncheon and a general discussion of Society affairs. C. F. Roth, New York, N. Y., joined the group and after luncheon Professor Larson was taken on a tour of the city and a visit to the M. G. M. Movie Studios, where various movie sets and sound stages were viewed, as well as movies in the making, and an inspection of the film laboratories was made.

At the evening meeting, Secy. H. M. Hendrickson read a telegram from Secy. A. V. Hutchinson of the Society regarding regulations for the reinstatement of former A.S.H.V.E. members.

Mr. Roth was presented and discussed the possibility of an A.S.H.V.E. meeting and exposition on the Pacific Coast in the near future.

Mr. Ott was called upon to introduce the guest of honor and gave a short but interesting description of President Larson's career.

President Larson gave a brief resumé of the work and activities of the A.S.H.V.E. and then spoke on The Economics of Good Construction as Related to Residence Heating. The lecture was illustrated with slides and proved very interesting to the membership. The value of insulation and weatherstripping was clearly brought out. After his address, President Larson asked for criticisms and answered questions from the membership, in an open discussion.

March 10, 1936. The regular monthly meeting of the Southern California Chapter, with 28 members and guests present, was held at the Rosslyn Hotel. Dinner was served at 6:30 p. m. and was followed by a business meeting.

Pres. Leo Hungerford read a letter from Secy. A. V. Hutchinson of the A.S.H.V.E. concerning Pres. G. L. Larson's visit to the local Chapter in April.

O. W. Ott proposed the idea of a Pacific Coast A.S.H.V.E. Meeting and it was suggested, after a short discussion, that such a meeting might be desirable in San Francisco in 1937 or in Los Angeles in 1938.

The main order of business for the evening was the discussion of the proposed Southern California Air Conditioning Code. A. H. Simonds, chairman of the committee, read the proposed code which was discussed section by section. E. H. Kendall moved that each section be voted upon by the membership as presented and this motion was seconded and carried.

Section 1 opened a great deal of discussion and was not approved. It was suggested that the definitions of winter, summer and all-year air conditioning be made to conform with those of the *Air Conditioning Manufacturers Association.*

Section 2 was approved.

Section 3 brought out considerable difference of opinion regarding outside and inside design conditions. It was suggested that the list be amplified to include the cities of Pasadena, Calif., and Yuma, Ariz.

Section 4 was approved but it was suggested that infiltration be included as part of the Design Load Calculations for summer as well as for winter air conditioning.

Section 5 on Design Air Quantity was approved but a number of the members seemed to think that the outside air requirements per person were too low and should be increased to 10 cfm minimum.

Section 6, Design Air Distribution, was the subject of earnest discussion. E. L. Ellingwood brought out that standards for air distribution were, in his opinion, most important, but hardest to state in a code. This section was left open for further study by the committee.

Section 7 was corrected to read that installations shall conform to the requirements of the Building and Safety Department of the "city having jurisdiction" instead of "City of Los Angeles." Item (*a*) concerning the requirements for refrigerant valves brought considerable objection from some of the members.

Section 8 was disapproved with the exception of the one portion stating that sheet metal work shall conform to the recommendations of THE A.S.H.V.E. GUIDE.

Sections 9, 10 and 11 were tentatively approved without much discussion.

It was suggested that the code, when finally completed by the committee and approved by the membership, be submitted to the various equipment manufacturers and consulting engineers for approval and their signature obtained if possible.

Secy. H. M. Hendrickson reports that the meeting adjourned at 10:00 p. m.

February 18, 1936. Pres. Leo Hungerford presided at the regular monthly meeting of the Southern California Chapter at the Rosslyn Hotel. A short business meeting followed the luncheon at 12:15 p. m. and 35 members and guests were present.

President Hungerford read a letter from A. V. Hutchinson concerning Pres. G. L. Larson's visit to the Chapter in April and it was decided to make this a night meeting. A letter from headquarters office concerning 1936 dues rates and qualifications for membership in the Society was read by Secy. H. M. Hendrickson.

President Hungerford and O. W. Ott, member of the A. S. H. V. E. Council, reported on the Society's Annual Meeting in Chicago and stressed the desirability and benefits of membership.

A preliminary draft of the proposed code of minimum requirements of Air Conditioning Standards, was presented by A. H. Simonds, chairman of the committee, which includes W. E. Barnum, Jr., E. H. Kendall and R. L. Stanley. Copies were distributed to the members present for reading and discussion.

It was decided to have a round table discussion of the proposed Standards at the March evening meeting.

A. W. Griewe, president of the Los Angeles Speakers' Club, gave a very interesting and educational talk to the members on the subject of Public Speaking as an Asset in Business.

January 14, 1936. Twenty-four members and guests were present at the Rosslyn Hotel, where dinner was served at 6:30 p. m., followed by a short business meeting of the Southern California Chapter.

Pres. Leo Hungerford led a discussion on the subject of Minimum Standards for Heating, Ventilating and Air Conditioning, and gave a brief summary of the standards that had been set up for Chicago. Several members expressed their ideas on the need for standards for air conditioning, and E. H. Kendall brought out that the code under consideration would not be limited to air conditioning alone, but would include ventilation, heating, etc.

The appointment of A. H. Simonds as chairman of the Committee to Formulate a Code of Minimum Requirements for Los Angeles was announced by President Hungerford and that Mr. Simonds would be assisted by one member from each of the various local equipment and engineering firms interested in this work.

Following the business meeting, the members were entertained by a group of travel movies interestingly presented by F. M. Locher of the Pacific Mutual Life Insurance Co. Five reels on the subjects given were shown, while Mr. Locher lectured on the interesting points of each: a trip to the top of the Eiffel Tower in Paris, a trip through the cathedrals of Milan and to Venice, a visit to Tahiti in the South Sea Islands, a trip to the top of the Jungfrau in Switzerland, and a visit in Switzerland and Yosemite in winter.

Washington, D. C. Chapter Discusses Smoke Abatement and Heating Equipment Design

April 8, 1936. Approximately 40 members and guests attended the regular meeting of the Washington, D. C. Chapter, which was held at Sholl's Cafe. After dinner, the meeting was called to order at 8:00 p. m. by Pres. W. A. Danielson.

The minutes of the preceding meeting were read and approved. The minutes of the March meeting of the Board of Governors were also read.

A letter from A. V. Hutchinson, secretary of the Society, asked for suggestions for improving THE GUIDE. President Danielson requested that the Chapter members cooperate with the Guide Publication Committee and send to Secy. M. D. Kiczales their suggestions, which will be forwarded to the Committee.

The Nominating Committee reported the following nominations for Chapter officers for the term beginning May, 1936 and ending May, 1937:

President—W. A. Danielson
Vice-President—T. H. Urdahl
Secretary—M. D. Kiczales
Treasurer—W. E. Kingswell
Board of Governors—E. J. Febrey, L. S. Ourusoff, and G. S. Frankel.

Secretary Kiczales read a report on the organization of the District of Columbia Council of Engineers and Architects. The Washington, D. C. Chapter has been invited to send two delegates and two alternates to represent the A.S.H.V.E. in the Council. The salient points of the constitution of the proposed Council were brought to the attention of the meeting and a general discussion of this report was entered into by T. H. Urdahl, J. E. Axeman, and C. S. Stock. The subject of membership in the Council was discussed. Mr. Axeman moved that delegates be appointed to represent the A.S.H.V.E. in the Council, and that the Chapter go on record as favoring affiliation with the Council and observance of its Constitution and By-Laws. The motion was seconded by Mr. Stock, and, after discussion, was passed.

A balance of $44.55 in the treasury was reported by the treasurer.

In the absence of R. H. Feltwell, chairman of the Membership Committee, President Danielson read a report that seven new members had been secured since the last meeting of the Chapter.

Mr. Febrey, chairman of the Constitution Committee, stated that a draft of the proposed Constitution had been prepared and a copy sent to each member of the Chapter, and that a few changes in this draft were necessary. After discussion it was decided to allow the members more time to study the proposed document and submit any amendments or changes to the Secretary in writing, prior to April 25, 1936. These written amendments and suggestions will be read at the next meeting and acted upon after which a vote will be taken.

Nominations for Chapter officers were then opened. After a general discussion of the desirability of retaining the same officers for the coming year, E. H. Lloyd moved that the nominations be closed, which was seconded by Mr. Febrey and unanimously carried.

Mr. Urdahl, chairman of the Program Committee, announced the feature of the meeting on May 13 to be an inspection under expert supervision of the air conditioning system of the Archives Building, preceded by dinner at 6:00 p. m. at the Hotel Harrington.

President Danielson introduced Mr. Kugel, Smoke Inspector of the District of Columbia. Mr. Kugel, formerly of Cleveland, O., told of the cooperation of the Smoke Committees of the *Cleveland Engineering Society* and the Cleveland Chapter of the A.S.H.V.E. in smoke abatement work in that city, and also emphasized the responsibility of the designing engineer for smoke conditions in a community. Mr. Kugel offered to speak at a future Chapter meeting and tell of the causes and results of smoke in a community.

A. J. Johnson, director of the Anthracite Institute Laboratory, Primos, Pa., was presented by President Danielson and delivered an interesting talk on The Design of Improved Heating Equipment. Mr. Johnson's remarks were very enlightening and set forth some theories proved by actual research. He described the design of new anthracite burning boilers for service water and house heating. Mr. Johnson stated that anthracite coal is not considered as a hydrocarbon, but has been found to be pure carbon with a large part of its hydrogen entrained mechanically rather than chemically. This discovery explains the complete absence of any sort of smoke under any conditions of combustion. The speaker explained that combustion with anthracite

is practically complete at a point coincident with the surface of the fuel bed and this points the way to an elimination of combustion space over the fire when this type of coal is to be used as fuel. Mr. Johnson said he believed that finally the boiler design that will operate most efficiently will incorporate the space formerly used for combustion for coal storage, will have minimum air supply above the grates equal to the former air leakage, will have more absorbing surfaces, and a resulting overall boiler size much smaller than the present boilers of equal capacity.

A question was raised concerning the District ruling on boiler design for domestic hot water. Mr. Urdahl moved that a committee be appointed to study the present District of Columbia regulations regarding direct coal fired domestic water heaters and recommend constructive revisions. This motion was seconded by Mr. Axeman.

After a rising vote of thanks to Mr. Johnson, the meeting adjourned at 10:15 p. m.

Western Michigan Chapter Inspects Steamship

April 13, 1936. The meeting of the Western Michigan Chapter was held at the Warm Friend Tavern, Holland, Mich., with 42 members and guests present.

The following members were proposed by the Nominating Committee for officers for the ensuing year:

President—L. G. Miller.
Vice-President—J. H. Van Alsburg
Secretary—E. I. Adams
Treasurer—C. R. McConner
Board of Governors—S. H. Downs, P. O. Wierenga, and S. W. Todd, Jr.

After the meeting adjourned at 10:00 p. m., an inspection trip was made through the steamship South America.

Secy. J. J. Troske reports that the May meeting will be held at the Green Ridge Country Club, Grand Rapids, Mich.

Western New York Chapter Considers A. C. Standards, Use of Gas in Air Conditioning

April 13, 1936. The April dinner meeting of the Western New York Chapter was held at the Touraine Hotel, Buffalo, with Pres. W. E. Voisinet presiding. Forty-eight members and guests were present. Minutes of the March meeting were read and approved.

The report of Treas. R. T. Thornton indicated that the finances of the chapter were in good condition and he requested that dues be paid promptly so that the present state may continue.

Joseph Davis, chairman of the Entertainment Committee, suggested that an entertainment program at the May meeting would be in order, and this plan was favorably received.

Three new applications for membership were reported by B. C. Candee, chairman of the membership committee.

P. S. Hedley, chairman of the Attendance Committee, expressed his appreciation to the members of his committee for their successful efforts to increase attendance, which has been evidenced since this group has been functioning.

A letter was read from A. V. Hutchinson, secretary of the A.S.H.V.E., requesting that the Chapter devote part of some meeting to a discussion of how the usefulness of THE GUIDE might be improved. President Voisinet appointed a committee to take charge of a discussion on the subject at an early chapter meeting.

The report of the Nominating Committee, composed of the Board of Governors, presented the following nominations for officers for the ensuing year:

President—P. S. Hedley.
First Vice-President—B. C. Candee.
Second Vice-President—J. J. Landers.
Secretary—C. A. Gifford.
Treasurer—L. P. Saunders.

It was also reported that the Board of Governors for the following year will consist of: M. C. Beman, Joseph Davis, Roswell Farnham, D. J. Mahoney, and W. E. Voisinet.

President Voisinet then called on Ted Messenger, secretary of the Air Conditioning Standards Committee, for a report. The Standards are completed and it is planned to have one more meeting of the group upon the return of L. A. Harding to Buffalo, to carefully check all phases of the recommendations before printing a supply for general distribution. The Winter Comfort Standards Sub-Committee, of which Mr. Beman is chairman, reported that their work will be completed in time to be incorporated in the Standards, which will then cover both summer and winter conditions.

With appropriate comment, President Voisinet introduced the speaker of the evening, W. E. Stark, research engineer, Bryant Heater Co., Cleveland, O. Mr. Stark mentioned three topics on which he would speak: Complete Air Conditioning with Gas; Silica Gel; and Cooling with Gas. By the use of lantern slides many interesting data and equipment were described pertaining to the subject, both for residential and industrial application.

The discussion which followed the address indicated great interest in the subject and Mr. Stark very ably answered many questions pertaining to the equipment described.

According to the report of Secy. J. J. Landers, a rising vote of appreciation was accorded the speaker for his splendid, entertaining and constructive presentation.

J. H. Leonard Dies

The death of Joseph Hamilton Leonard came as an unexpected sorrow to his host of personal friends and business associates. Mr. Leonard died on Monday, February 24, in the Winnipeg General Hospital at the age of 60 and funeral services were held on February 26 at All Saints' Anglican Church, with interment in St. John's Cemetery, Winnipeg, Man., Can. He had been a Member of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS since 1931 and was also a member of the Manitoba Chapter.

Mr. Leonard was born in Dublin, Ireland, on December 28, 1875. He came to Canada 45 years ago and lived in Winnipeg during the last 35 years. After he first came to America he was employed by Crane Co. and located in the company's offices at St. Paul, Omaha, and Winnipeg. For a number of years he operated the J. H. Leonard Co. in Winnipeg, representing several well-known manufacturers of heating and ventilating equipment. In 1911 he was appointed manager of the Winnipeg sales office of C. A. Dunham Co., Ltd.

Mr. Leonard's quiet genial manner, twinkling eye, clipped speech and hearty laughter were expressions of a kindly personality which made and held friends. He was a member of the Masonic Order, the Independent Order of Foresters and the Winnipeg Winter Club.

The Officers and Council of the Society unite in extending their sincere sympathy to his widow and his daughter, Mrs. J. S. Martin, of Winnipeg, who survive.

Charles E. Monday

The death of Charles E. Monday occurred on March 7, 1936, at Philadelphia, Pa., where for many years he was head of Charles E. Monday & Co., heating engineers and contractors.

Mr. Monday was born in 1859 at Philadelphia, attended public schools in the city, and he had more than 50 years practical experience as a mechanical engineer.

In 1920 Mr. Monday affiliated with the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS as a Member and at the meeting of the Council in January, 1936, action was taken conferring Life Membership upon him.

The Officers and Council regret to learn of his passing and have sent an expression of their sorrow to members of Mr. Monday's family.

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate to membership by letter ballot. During the past month 39 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by May 15, 1936, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
BALL, WILLIAM, Pres., Interstate Htg. & Plbg. Co., Kansas City, Mo.	C. A. Weiss Carl Clegg	F. A. Sheppard G. L. Bliss
BERGHOEFER, V. A., Vice-Pres., Sterling Engrg. Co., Milwaukee, Wis. (*Advancement*).	F. G. Weimer J. S. Jung	W. F. Noll C. H. Randolph
BERGLUND, N. W., Draftsman, York Ice Machinery Corp., Los Angeles, Calif.	H. M. Hendrickson W. E. Barnum, Jr.	E. H. Kendall H. H. Bullock
BUCK, D. T., Pres., Buck Engrg. Co., Inc., Freehold, N. J.	R. P. Strevell A. R. Johnson (*N.S.P.E.*)	P. S. Craeger (*Non-Member*) W. J. Schiverea (*Non-Member*)
CARRIER, E. G., Sales Engr., Carrier South Africa (Pty.) Ltd., Johannesburg, Transvaal, South Africa (*Advancement*).	V. S. Day Donald French	W. A. Grant L. L. Lewis
CLEVELAND, C. C., Member of Firm, Johnson & Cleveland, Bradford, Pa.	C. H. Graham W. E. Voisinet	Joseph Davis B. C. Candee
DULLE, W. L., Asst. Secy., E. E. Souther Iron Co., St. Louis, Mo.	M. J. Holloran (*Non-Member*) Bruce Haines (*Non-Member*)	N. L. Pierson (*Non-Member*) F. E. Finley (*Non-Member*)
EARL, WARREN, Sales Engr., W. C. Dance, Inc., Oklahoma City, Okla.	E. W. Gray R. G. Dolan	S. L. Rolland E. S. Constant
ELWOOD, W. H., Br. Mgr., Holland Furnace Co., Ithaca, N. Y.	E. H. Woods W. M. Sawdon	J. W. Williams V. W. Cherven
FAY, D. P., Student, Pratt Institute, Brooklyn, N. Y.	J. L. Munson F. W. Price (*Non-Member*)	L. B. Pope (*Non-Member*) H. H. Bond (*Non-Member*)
FORSLUND, O. A., Partner & Mgr., Forslund Pump & Machinery Co., Kansas City, Mo.	N. W. Downes Carl Clegg	L. A. Stephenson G. L. Bliss
FOSS, E. R., Southern Mgr., The Powers Regulator Co., Atlanta Ga.	C. L. Templin F. W. Clare	I. B. Kagey W. J. McKinney
FRENTZEL, H. C., Chief Engr., The Heil Co., Milwaukee, Wis.	C. H. Randolph Ernest Szekely	J. H. Volk J. S. Jung
GRABER, ERNST, Engr., Minneapolis-Honeywell Reg. Co., New York, N. Y.	H. W. Fiedler C. R. Hiers	L. B. Miller Curtis Delano (*Non-Member*)
GREBEN, DAVID, Consulting Engr., New York, N. Y.	D. D. Kimball A. J. Offner	H. W. Fiedler John James
HILL, C. F., Engr., Carrier-Brunswick Internat'l., Newark, N. J.	J. H. Holton Donald French	V. S. Day W. A. Grant
HOBBS, W. S., Owner & Mgr., Wm. S. Hobbs, Swarthmore, Pa.	Richard Tunis (*Non-Member*) W. A. De Caindry (*Non-Member*)	E. S. Flynn (*Non-Member*) C. E. Campbell (*Non-Member*)
HOCKENSMITH, F. E., Chief Htg. Engr., Lennox Furnace Co., Syracuse, N. Y.	C. H. Graham A. A. Barns	H. T. Betlem C. F. Woese
HOLMES, P. B., Br. Mgr., National Radiator Corp., Washington, D. C.	R. H. Feltwell T. H. Urdahl	W. E. Kingswell E. J. Febrey
HOWE, W. W., Div. Sales Engr., Pacific Gas & Elec. Co., Sausalito, Calif. (*Reinstatement*).	W. A. Russell N. W. Downes	C. W. Adams Benjamin Natkin
ISETT, W. M., Pres., C. B. Isett & Son, Inc., Chicago, Ill.	M. J. Fitzgerald L. O. Krez	Fred Lautenschlager A. B. Martin
IVERSON, H. R., Engr. & Salesman, The Trane Co., Washington, D. C.	T. H. Urdahl L. F. Nordine	R. H. Feltwell M. D. Kiczales
JOHNSON, W. G., Student, University of Illinois, Urbana, Ill.	W. H. Severns P. E. Mohn (*A.S.M.E.*)	J. A. Goff (*A.S.M.E.*) H. J. Macintire (*A.S.R.E.*)
LARSON, C. P., Sales Engr., The Insulite Co., Chicago, Ill.	F. B. Rowley A. B. Algren	J. V. Martenis R. E. Backstrom
LAUFKETTER, F. C., Chief Engr. & Supt., Jefferson Hotel, St. Louis, Mo.	C. R. Davis E. E. Carlson	W. N. O'Brien L. W. Moon
LUND, C. E., Warm Air Htg. Inspector, City of Minneapolis, Minneapolis, Minn. (*Advancement.*)	F. B. Rowley A. B. Algren	R. E. Backstrom H. E. Gerrish
MCKITRICK, W. D., Htg. Engr., Mills, Rhines, Bellman & Nordhoff, Inc., Toledo, Ohio.	Quentin Treadway W. G. Schlichting	H. C. Baker John Gillett (*A.S.M.E.*)

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
MILENER, E. D., Secy., Industrial Gas Section, American Gas Assn., New York, N. Y.	H. L. Whitelaw E. R. Downe	W. R. Zuhlke F. B. Howell
MILLER, G. F., Mfr's. Agent, C. A. Dunham Co., Washington, D. C.	E. J. Febrey W. E. Kingswell	W. H. Littleford T. H. Urdahl
NEST, R. E., Asst. Chief Engr., Anchor Post Fence Co., Baltimore, Md.	T. H. Smoot W. E. Kingswell	B. E. Shaw A. H. Senner (*Non-Member*)
PATERSON, F. C., JR., Pres. & Treas., F. C. Paterson & Co., Inc., Bradford, Pa. (*Reinstatement & Advancement*).	B. C. Candee M. C. Beman	G. F. Erdle Joseph Davis
PAUL, D. I., Sales Engr., Gurney Fdry. Co., Ltd., Toronto, Ont., Can. (*Advancement*).	E. H. Gurney M. W. Shears	W. R. Blackhall William Philip
SCARLETT, W. J., Sales Engr., Carrier Engrg. Corp., Kansas City, Mo.	H. W. Moore J. J. La Salvia	C. E. Lewis M. J. Stevenson
SCHERRER, L. B., Engr. & Estimator, Housing Service, Inc., St. Louis, Mo.	G. W. F. Myers E. E. Carlson	C. E. Hartwein L. W. Moon
STERNER, D. S., Sales Supervisor, Tenn. Public Service Co., Knoxville, Tenn.	C. E. Lewis A. I. Brown	E. B. Peters (*Non-Member*) P. M. Anderson (*Non-Member*)
SWANSON, GERTRUDE L., Estimator, 5100 Highland Ave., Kansas City, Mo.	W. A. Danielson G. F. Mox (*Non-Member*)	I. F. Albin (*Non-Member*) K. E. Whitman (*Non-Member*)
SWISHER, S. G., JR., Sales Engr., The Trane Co., La Crosse, Wis. (*Advancement*).	R. N. Trane R. H. Anderegg	M. W. Miller L. W. Hessler
VAN NUYS, J. C., Student, Pratt Institute, Brooklyn, N. Y.	J. L. Munson L. B. Pope (*Non-Member*)	F. W. Price (*Non-Member*) H. H. Bond (*Non-Member*)
WEISS, C. A., Mgr., Kornbrodt Kornice Kompany, Kansas City, Mo. (*Advancement*).	Carl Clegg W. A. Russell	F. A. Sheppard N. W. Downes

Candidates Elected

In past issues of the JOURNAL of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

MEMBERS

BAKER, G. R., Pres., G. R. Baker Co., Ltd., Toronto, Ont., Can.
BAMOND, M. J., Engr., Reynolds Corp., Chicago, Ill.
BEVINGTON, C. H., Br. Mgr., J. P. Marsh Corp., Chicago, Ill.
BROWN, DAVID, Plbg. & Htg. Contractor, New York, N. Y.
CROSS, F. G., Sales Mgr. & Engr., Fulton Sylphon Co., New York, N. Y.
DEAN, C. H., Htg. Engr., Oklahoma Natural Gas Co., Tulsa, Okla.
DICKENSON, M. E., Vice Pres. & Gen. Mgr., Livingston Stoker Co., Ltd., Hamilton, Ont., Can.
FIDELIUS, W. R., Sales Engr., Fitzgibbons Boiler Co., New York, N. Y.
HARSCH, R. J., Chief Engrg. Draftsman, U. S. Navy Yard, Brooklyn, N. Y.
HERTZLER, J. R., Mgr. Air Cond. Div., York Ice Machinery Corp., York, Pa. (*Advancement*).
JONES, SPRAGUE, Pres., Sprague Jones, Inc., Toledo, Ohio.
MCEWAN, E. E., Mgr. Air Cond. Div., Frigidaire Corp., New York, N. Y.
MOLLENBERG, H. J., Refrig. Engr. & Vice-Pres., Mollenberg Betz Machine Co., Inc., Kenmore, N. Y.
PATRICK, H. M., Partner, Chubbuck & Patrick, Ardmore, Pa. (*Reinstatement and Advancement*).
ROBINSON, A. S., Vtg. & Htg. Engr., E. I. Du Pont de Nemours Co., Wilmington, Del.
RUSSELL, E. A., Chief Engr., Vapor Car Heating Co., Chicago, Ill.
TONRY, R. C., Mgr., Wiedebusch Plbg. & Htg., Fairmont, W. Va.
WILSON, R. A., Sales Engr., Minneapolis-Honeywell Reg. Co., Cleveland, Ohio.
WORTHING, S. L., Consulting Engr., Grand Rapids, Mich.

ASSOCIATES

BEACH, W. R., Sales Engr., Cleveland Elec. Ill. Co., Cleveland, Ohio.
DEWAR, W. G., Mgr. Oil Burner Div., Canadian Fairbanks-Morse Co., Ltd., Montreal, Que., Can.
MINOR, F. K., Dist. Repr., American Air Filter Co., Cleveland, Ohio.
ROBINSON, D. M., Sales Engr., Buffalo Forge Co., Washington, D. C.
RUSSELL, W. B., Engr., Russell Furnace Co., Spokane, Wash.

JUNIORS

ADLER, J. C., Sales Mgr., Frigidaire Corp., New York, N. Y.
ETLINGER, M. J., 2015 University Ave., New York, N. Y.
FISHER, J. T., Air Cond. Engr., National Electrical Supply Co., Washington, D. C.
FREEMAN, J. C., Designer, O. W. Ott, Consulting Engr., Los Angeles, Calif.
HUGHES, L. K., Gen. Mgr., Howard Furnace Co., Toronto, Ont., Can.
LILJA, O. L., Mech. Engr., Toltz, King & Day, St. Paul, Minn.
NELSON, A. W., Sales Engr., American Radiator Corp., Albany, N. Y.
WEINFELD, CHARLES, Sales Engr., Ilg Electric Vtg. Co., Detroit, Mich.
WITHERIDGE, D. E., Sales Engr., W. A. Witheridge Co., Saginaw, Mich.

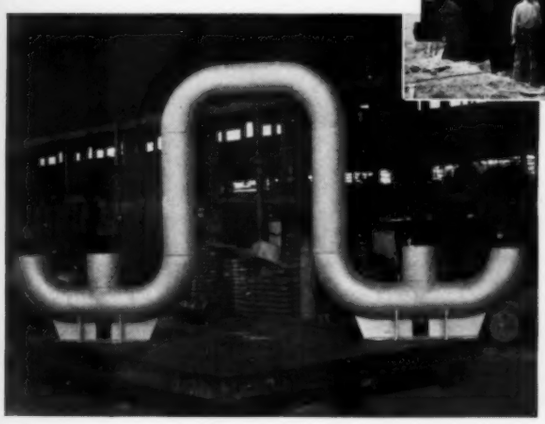
STUDENTS

BAKER, R. H., Student, Case School of Applied Science, Cleveland, Ohio.
BREZINA, E. A., Student, Case School of Applied Science, Cleveland, Ohio.
COHEN, HARRY, Student, Case School of Applied Science, Cleveland, Ohio.
CURTIS, W. A., Student, Case School of Applied Science, Cleveland, Ohio.
FOLLETT, T. L., Student, Case School of Applied Science, Cleveland, Ohio.
FULLER, J. H., Student, Case School of Applied Science, Cleveland, Ohio.
HARVEY, R. A., Student, Case School of Applied Science, Cleveland, Ohio.
KAIN, E. M., Student, Case School of Applied Science, Cleveland, Ohio.
HERMAN, N. B., Student, University of Minnesota, Minneapolis, Minn.
LEE, R. T., Student, University of Illinois, Urbana, Ill.
MAROTTA, J. A., Student, Case School of Applied Science, Cleveland, Ohio.
MITCHELL, J. G., Student, University of Minnesota, Minneapolis, Minn.
STERLING, J. G., JR., Student, Case School of Applied Science, Cleveland, Ohio.
TANKER, G. E., Student, Case School of Applied Science, Cleveland, Ohio.
TECKMYER, F. C., JR., Student, Case School of Applied Science, Cleveland, Ohio.
TRUITT, G. S., Student, Purdue University, W. Lafayette, Ind.
WALKER, J. E., Student, Case School of Applied Science, Cleveland, Ohio.
WILLER, M. D., Student, Case School of Applied Science, Cleveland, Ohio.

MIDWEST

FABRICATED PIPING
is *better piping*

THREE well equipped plants strategically located and manned by highly skilled organizations assure pipe fabrication that is accurately to dimension, promptly delivered and in every other way in accordance with the most modern practices. An unexcelled store of specialized piping experience is freely available; this has frequently been responsible for simplification of piping design and substantial cost reduction.



MIDWEST WELDING FITTINGS

Midwest Welding Ells alone have the *longer tangents* that reduce installation time and expense and also save pipe. Other important advantages are dimensional accuracy and uniformity resulting from final working in compression—uniform wall thickness—stress relieved—etc. The complete line of Midwest Welding Fittings is described in Bulletin WF-10; ask nearest office for a copy.

★

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PIPING & SUPPLY COMPANY, Inc.

Main Office: 1450 South Second St., St. Louis, Mo.

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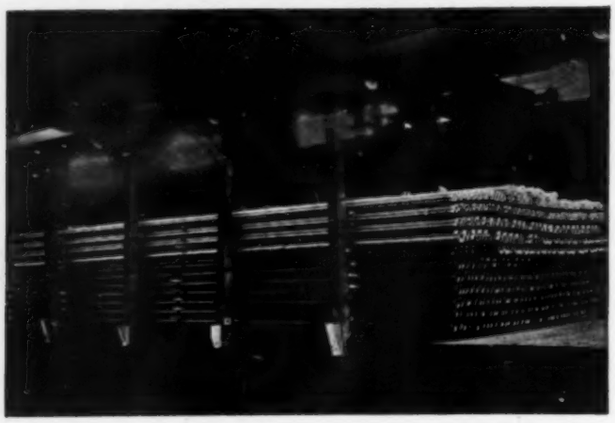
Sales Offices: Chicago—20 N. Wacker Drive Bldg. • Houston—1708 Second Nat. Bank Bldg. • Los Angeles—520 Anderson St. • New York—(Ballwood Div.)—30 Church St. Tulsa—533 Mayo Bldg.

IF YOU WANT PIPE



IN LONG LENGTHS

On every piping job, there are places where long lengths will shorten installation time, reduce fitting expense and make possible neater work.

Now you can obtain pipe in extra long lengths—without cross-weld—Fretz-Moon Pipe. Because it is made by the exclusive "continuous process," it may be had in double random (or even longer) lengths. And not one bit of the well-known Fretz-Moon quality is sacrificed.

Every length, no matter how long, is straight as an arrow, true in size, perfectly round, uniform in structure, tightly welded, clean inside and outside, and easy to bend, cut or thread at any point. Every inch is as highly ductile as every other inch—without a single hard or burnt spot to cause trouble. It is ideal for coiling.

Fretz-Moon Pipe is available in long lengths in sizes from ⅛-inch to 2½-inch. Write for full information.

FRETZ-MOON TUBE CO., INC.
BUTLER • PENNA.

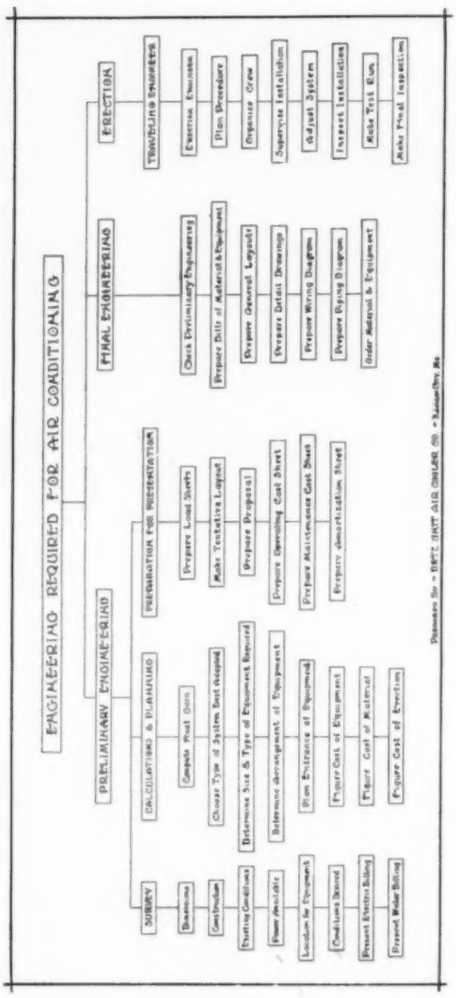
FRETZ-MOON PIPE
BLACK AND GALVANIZED

Engineering and Equipment for Air Conditioning Charted

By **H. D. Betz***

FEW prospective purchasers of an air conditioning system realize the important role that engineering plays in determining the required capacity, selecting the system best adapted to the particular requirements, and in designing the job. Likewise, the amount of equipment and material which goes into a complete air conditioning system is not always appreciated.

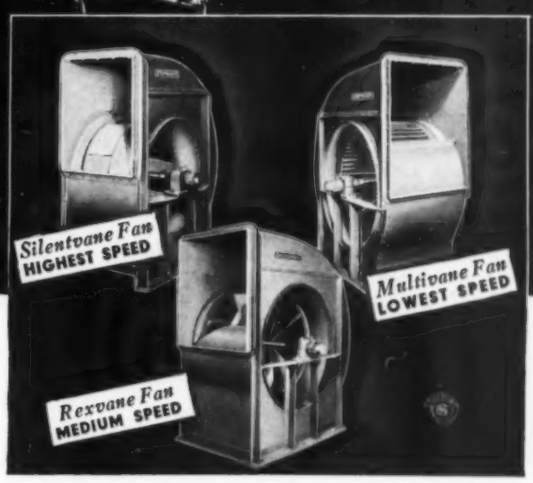
We have therefore prepared this chart and the one shown on page 104 to aid the prospective owner in visualizing what is involved. By calling attention in this way to the equipment, material, labor, preliminary survey work, and the engineering, the effort represented by a well prepared proposal is quickly realized and the importance of careful design and selection is brought home.



*President, Betz Unit Air Cooler Co., Kansas City, Mo.

Fans— MADE THE STURDY STURTEVANT WAY

IN WIDEST AVAILABLE VARIETY OF ✓ SPEEDS ✓ CAPACITIES ✓ OTHER CHARACTERISTICS—



3 DISTINCT LINES of sturdy Sturtevant Centrifugal Fans . . . providing such a comprehensive variety of speeds, capacities and other characteristics that any fan requirement may be met with exceptional exactness.

3 new lines . . . incorporating up-to-the-minute improvements in design and construction. Fans built the typical Sturtevant way . . . to thrive on tough service. And soundly engineered from stem to stern . . . on the basis of Sturtevant's 70 years of Air Engineering Experience.

Silentvane: High speed. Backwardly curved blades. Limiting Horsepower Characteristic. (Catalog 381-1).

Rexvane: Medium speed. The modern, improved "paddle wheel", with greatly increased capacity. (Catalog 414).

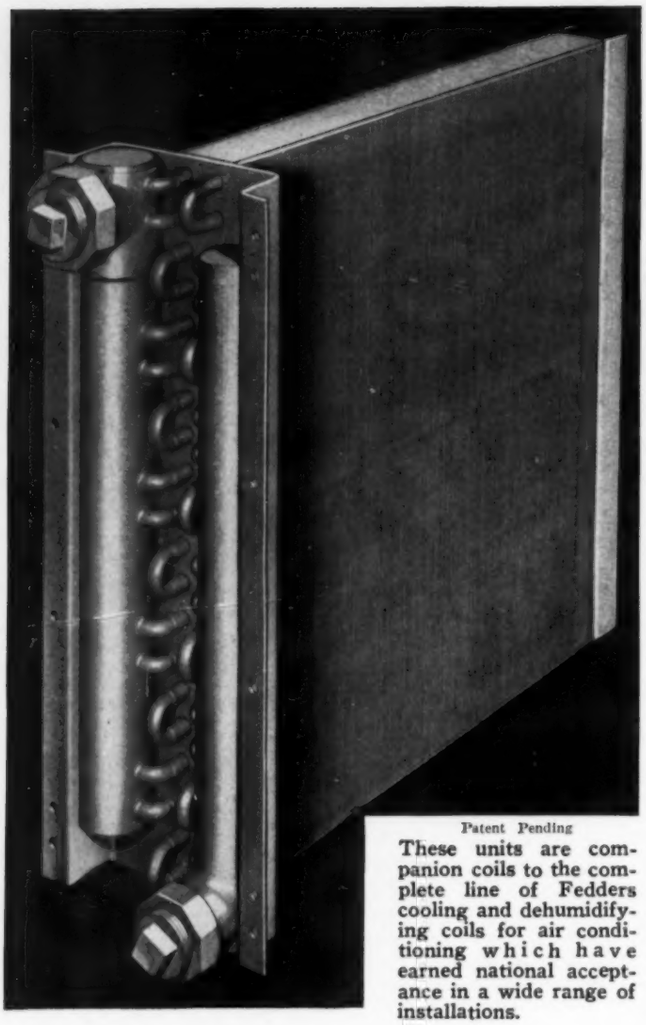
Multivane: Low speed. Forwardly curved blades. Admirably adapted to ventilation requirements. (Catalog 271-1).

B. F. Sturtevant Company, Hyde Park, Boston, Mass.
Branches in 33 principal cities

Sturtevant
REG. U. S. PAT. OFF.

Puts Air to Work

SPECIALISTS IN AIR ENGINEERING FOR OVER 70 YEARS



Patent Pending

These units are companion coils to the complete line of Fedders cooling and dehumidifying coils for air conditioning which have earned national acceptance in a wide range of installations.

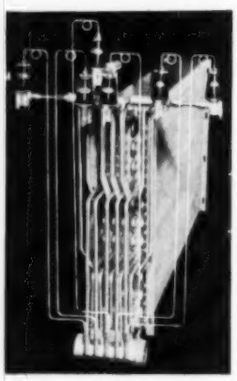
FEDDERS *Announces*

a Complete Line of

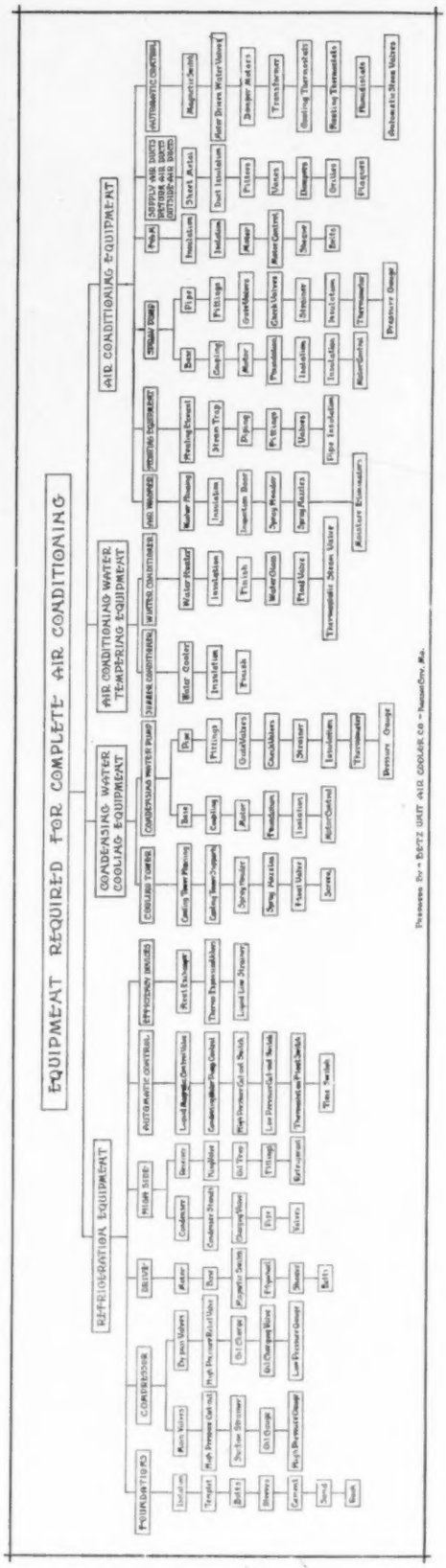
ALL-COPPER HEATING SURFACE

In addition to the nationally known line of cooling and dehydrating coils, Fedders presents blast heating surface catalogued in standard sizes,—on a package basis. Features include copper fins and copper tubes, high ratio of prime surface, manifolded for correct steam distribution, floating provision for relief of expansion stresses, 300 lb. allowable working pressures. Complete data in Fedders Bulletin 101, data on cooling coils given in Bulletin 91. Write for your copies.

FEDDERS MANUFACTURING CO.
Buffalo, N. Y.



Pat. No. 2,023,749
COOLING COILS
FOR REFRIGERANT
AND COLD WATER


EQUIPMENT REQUIRED FOR COMPLETE AIR CONDITIONING
REFRIGERATION EQUIPMENT
CONDENSING OR COOLING EQUIPMENT
AIR CONDITIONING WATER TEMPERING EQUIPMENT
AIR CONDITIONING EQUIPMENT

Air conditioning equipment chart as described on page 102 by H. D. Betz

James Gamble Rogers, Architect; Fred. Brutschy, Sanitary Engineer; W. G. Cornell Company, Plumbing Contractors

World's Largest Hospital Uses Fairbanks Valves

Probably in no type of building is dependable performance of valves and other equipment so important as in a hospital. No chances can be taken where human life is at stake.

In keeping with the thoroughly modern construction of the Presbyterian Medical Center, New York, the men responsible for the construction of this monumental structure selected Fairbanks Valves. That they chose wisely is demonstrated by the fact that, after years of service, the Fairbanks Valves have proven their dependability.

Quality in a thing is not always easy to *see*—but lack of quality can't fool time.

Over 50 years of specialization in the manufacture of valves has taught us many things which long experience alone can disclose about the building of reliable, long-lasting valves.

Write for our new catalog No. 21, illustrating and describing more than 140 valves, or simply mail the coupon.

THE FAIRBANKS COMPANY

Manufacturers of Valves, Hand Trucks and Wheelbarrows

396 Lafayette St., New York, N. Y.

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MAIL COUPON TODAY!

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Without obligation on our part, kindly send a copy of your valve catalog No. 21.

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Air Conditioning Cooling

Ask Trane first

— about all cooling problems

Let TRANE Engineers help you with all of your cooling problems. They will be glad to consult with you in the lay-out and design on every type air Conditioning installation. Get in touch with any of our Branch Offices or write the factory direct.

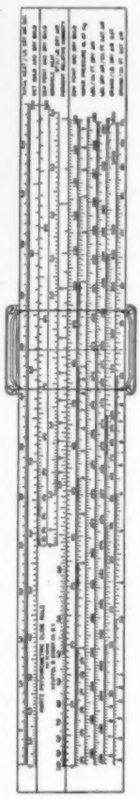
The TRANE Company also manufactures a complete line of Unit Heaters, Blast Coils, Product Coolers, and Heating Specialties.

THE TRANE COMPANY
BRANCHES IN ALL PRINCIPAL CITIES
LA CROSSE, WISCONSIN
In Canada—Mowat & King Sts. W.—Toronto
TRANE

Equipment Developments

For your convenience in obtaining more information about any of this equipment, see coupon on page 134. Add the new products and companies listed here to your Directory Section which you received in your January 1936 Heating, Piping and Air Conditioning and thus keep your records of sources of supply up to date throughout the year . . . Single asterisk (*) indicates equipment not listed in Directory Section; double asterisk (**) equipment and manufacturer not listed.

Psychrometric Slide Rule Solves A. C. Problems



No. 201—"Kurtz" psychrometric slide rule has been designed to replace psychrometric charts and tables and to afford a complete and accurate means of determining psychrometric values for solving air conditioning problems. The rule is so arranged that if two of the four fundamental psychrometric factors—dry bulb temperature, wet bulb temperature, dew point temperature and relative humidity—are known, the other two may easily be determined by one or two settings of the slide.

In addition, values may be read directly from dry bulb temperature for lb of dry air per cu ft of dry air and sensible heat in Btu per lb of dry air; from wet bulb temperature: total heat in Btu per lb of dry air in a saturated mixture; from dew point temperature; vapor pressure in inches of mercury, lb of dry air per cu ft of saturated air, grains of moisture per lb of dry air saturated with moisture, and grains of moisture per cu ft of saturated air. Thus the results for partially saturated mixtures may be evaluated and complete information on any possible mixture of air and water vapor (within the temperature range of the slide rule) may be obtained.

Tables and fundamental formulas, pertinent to air conditioning in general, are printed on the back of the rule for handy reference.

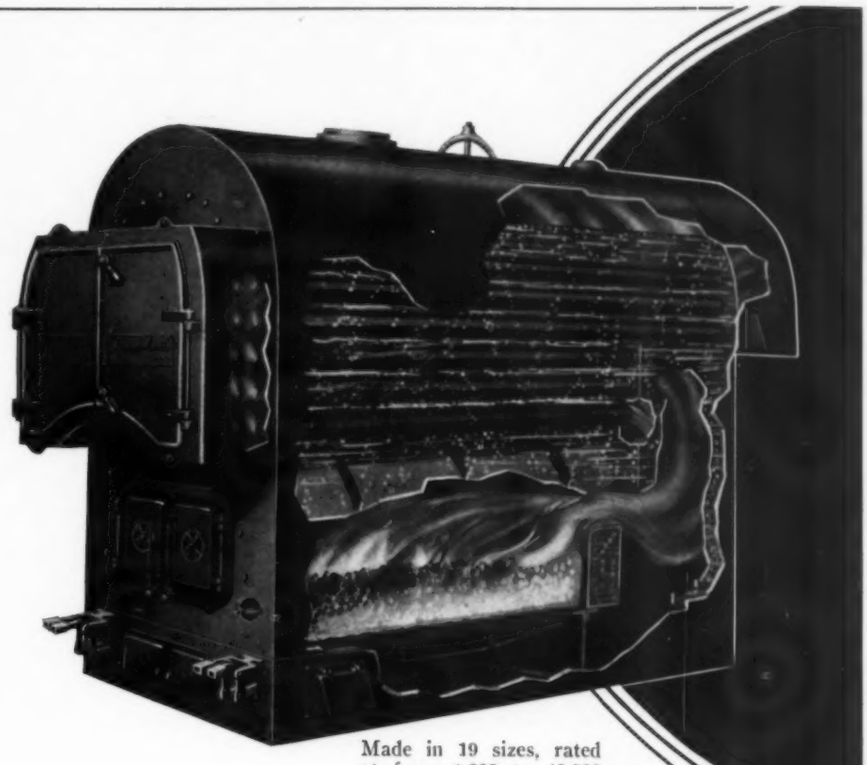
The rule is 11 x 1⅝ in. and it is finished in white enamel and black figures. It is based upon the standard barometric pressure of 29.92 in. of mercury.—Keuffel & Esser Co., Hoboken, N. J.

Convector Gate Valve is Packless

No. 202—New packless convector gate valve embodies all the features of the older model announced a year ago and adds the packless feature to valves located within enclosures where repacking operations are difficult.

Equally adapted to steam or hot water heating systems, the valve was designed for convector type radiators where limited space is available for installation and operation of a gate valve. It is compactly designed and easily installed by screwing the male thread into the bottom connection of the convector before the radiator is placed in position. The female connection is screwed directly onto the stub. When the radiator is installed it is only necessary to tighten the tail nut and the valve is ready for operation.

WHICH DO YOU WANT ?



Made in 19 sizes, rated at from 1,800 to 42,500 sq. ft.

A Boiler Made to a Specification

Or One Made to a Reputation?

Or Both?

With you, doesn't a *specification* tell you of materials and construction? While a *reputation* is what a thing will do—or *won't*.

We are ready to give you detailed specifications of this steel boiler—and we are sure it will fill your requirements.

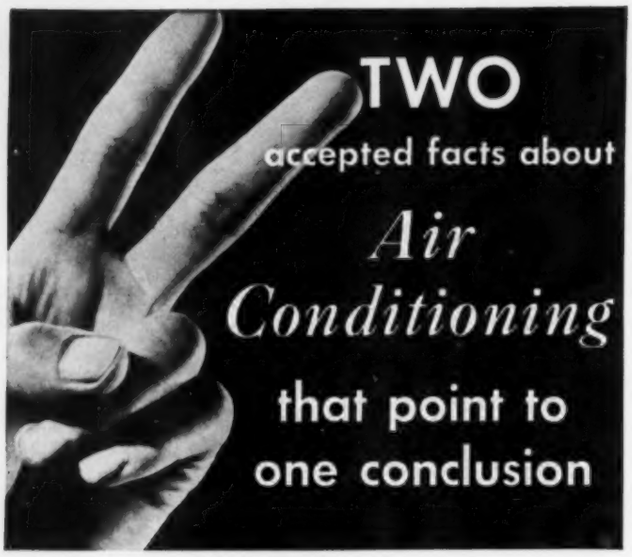
But what of the reputation side? You may know the reputation of Burnham's cast iron boilers, and not know a thing about the steel. Still you do know the Burnham reputation.

So far as we are concerned we would ask you to use a Burnham, because of Burnham's reputation. On this basis you really have no need to bother about specifications. What we say a boiler *is* and *will do*, you can depend upon. This, therefore, is what we want to say about this Welded Steel Boiler, that it is *Burnham-Made*.

Burnham Boiler Corporation

IRVINGTON, NEW YORK ZANESVILLE, OHIO

Representatives in All Principal Cities of the United States and Canada



MANY business men and families will discuss with you the benefits of summer air conditioning. Your recommendations must be based on confidence in the manufacturer. Hence it is wise to recommend the product of a reliable and experienced authority. Consider these facts:

FIRST FACT: Summer air conditioning is basically cooling and dehumidifying.

SECOND FACT: The accepted method of cooling and dehumidifying is by electric refrigeration.

CONCLUSION: These simple facts clearly indicate the wisdom of recommending the air conditioning systems of the organization that represents the *most experience in the design, manufacture and application of electric refrigeration equipment.*

Delco-Frigidaire Conditioning Corporation, with its General Motors background, is that organization. Here's why:

DESIGN — All modern air conditioning systems are built around the famous cooling medium, FREON, the development of which was sponsored by General Motors. Delco-Frigidaire equipment specifically was designed for use with FREON.

MANUFACTURE — Through Frigidaire, General Motors is the world's largest builder of refrigeration equipment. This skill in precision manufacturing produces equipment which does *more work* for *less cost.*

APPLICATION — Virtually every type of business and industry has Delco-Frigidaire installations. These applications are numbered by thousands.

Before you make any commitments for air conditioning, get ALL the proof. The coupon will bring it. →

HPAC6

Delco-Frigidaire Conditioning Corporation, Dayton, Ohio

Please give me full details about Delco-Frigidaire air conditioning systems.

*Name*_____

*Address*_____

*City and State*_____

DELCO-FRIGIDAIRE CONDITIONING CORPORATION

Automatic Heating **DAYTON, OHIO** *Air Conditioning*

PRODUCTS OF GENERAL MOTORS

Made in ½, ¾, 1 and 1¼ in. sizes, the valve comes with a nickel finish and a black non-heating handle that is easily accessible through the inlet arch of the enclosure.—American Radiator Co., Accessories Div., 40 W. 40th St., New York, N. Y.

Portable Summer Air Conditioner

No. 203—New self-contained portable summer air conditioner for individual rooms, offices, sick rooms, small shops and homes utilizes an air cooled condenser, has a ¾ ton capacity. Steel

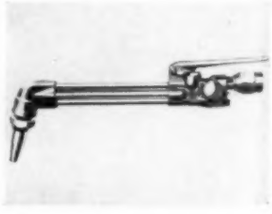
casing, attractively finished in dark walnut, is 40 in. high, 36 in. wide and 18 in. deep.

Location beneath a window through which by means of a duct connection outside air is brought in for condensing purposes and for ventilation is required. Aside from this an electrical connection from a standard floor or baseboard outlet is all that is necessary.

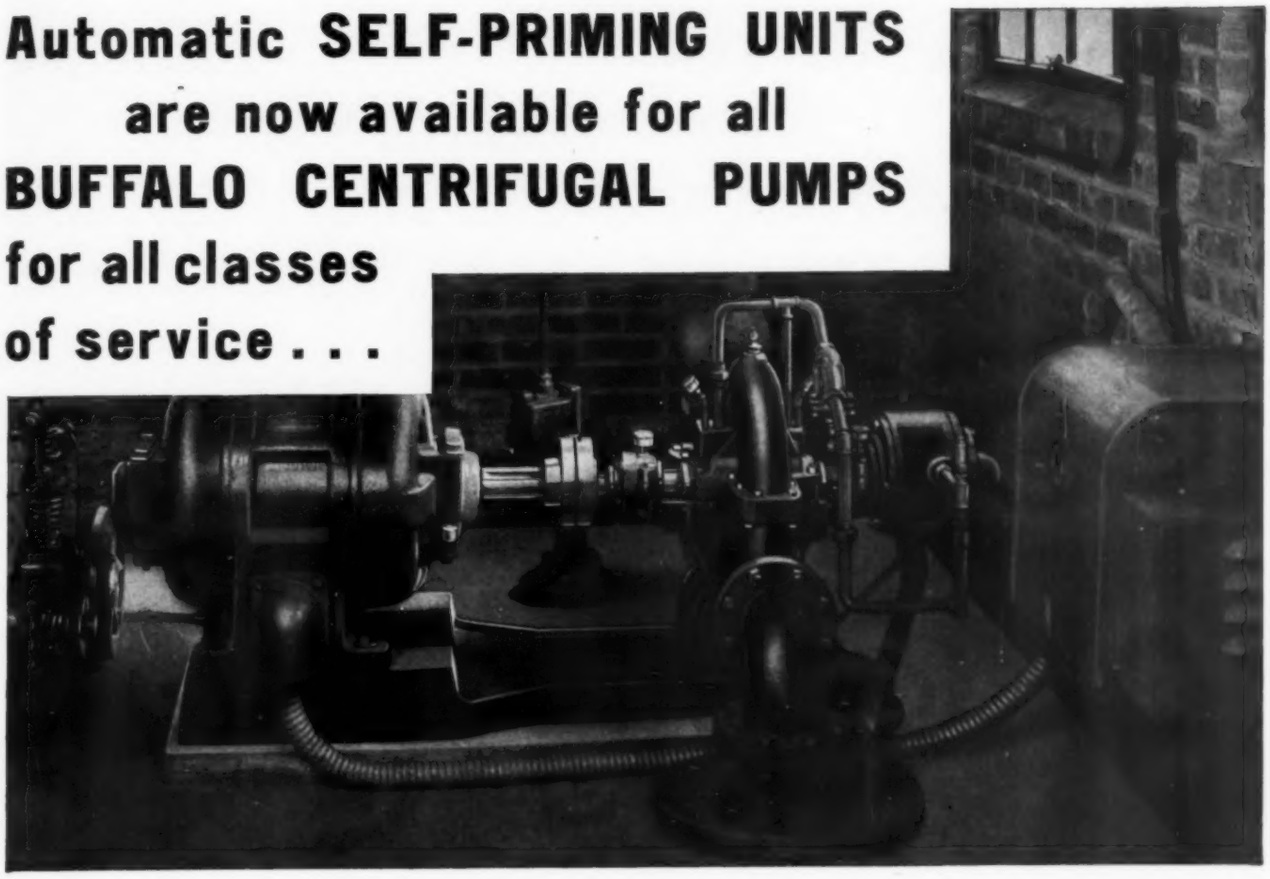
A centrifugal fan circulates 250 cfm of cooled and dehumidified air; a single unit thus has capacity for spaces from 1500 to 3000 cu ft, according to the engineers of the company. The refrigerating machine and evaporator coils, fans and controls are all contained within the cabinet, which may be equipped with casters for moving from room to room.—Carrier Engrg. Corp., 850 Frelinghuysen Ave., Newark, N. J.

Oxy-Acetylene Cutting Attachment

No. 204—New oxy-acetylene cutting attachment (known as "Oxweld Type CW-22") will handle light sheet metal as well as all but the heaviest work at speeds and efficiency equal to those of the full size cutting blowpipe, according to the manufacturer. The attachment operates on low or medium pressure acetylene. Sturdy, smooth operation at all times and all pressures is given by the streamline injector and the improved cutting valve, with removable seat, centralized under the cutting lever. The mixed gas passage is formed by three "Ambrac" tubes. The length, and four 90 deg changes of direction, afforded by this construction gives exceptional flashback resistance. The body and head are designed to combine strength and lightness, the body being of forged bronze while the head is a manganese bronze forging.—Linde Air Products Co., 30 E. 42nd St., New York, N. Y.



Automatic SELF-PRIMING UNITS are now available for all BUFFALO CENTRIFUGAL PUMPS for all classes of service . . .



• • • *They cost less to install, operate and maintain*

Automatic self-priming is easy and positive in Buffalo Pumps equipped with Self-Priming Units. This feature has been carefully engineered for maximum efficiency and long service. It is available for application to single and double suction pumps to meet any installation requirement.

No costly excavation

In sewage pumping and other similar services calling for single suction pumps mounted above the liquid level, the need of excavating for an expensive pit in which to locate motor and pump is eliminated. Installation cost is thus vastly reduced.

This same advantage applies to automatic water supply systems where double suction pumps are required.

Flexibility in design meets all classes of service

Buffalo Self-Priming Units, for single or double suction pumps can be placed between coupling and pump bearing, outside of pump bearing or at the outer end of motor shaft. This flexibility in design enables Buffalo to meet practically every installation condition for service—sump, drainage, sewage or general service, and assures easy access to all parts for inspection and maintenance.

Engineering service available

Behind Buffalo Self-Priming Pump Units is an engineering service to help you meet your requirements most effectively and at lowest operating cost. Ask for engineering details by filling in the coupon below and mailing it today.

These features assure savings

All working parts are above liquid to be pumped and completely accessible.

Perfectly balanced, vibrationless rotors.

Generally higher in efficiency than vertical pumps.

Positive priming without use of foot valve.

May be installed near or remote from pit.

Quiet — no long shafts — fewer bearings — simple.

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CINCINNATI
622 Broadway

CLEVELAND
418 Rockefeller Bldg.

DENVER
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The Coon DeVisser Co.
2051 W. Lafayette Blvd.

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P. O. Box 144

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KANSAS CITY
315 Dwight Bldg.

KITCHENER
Canada Pumps, Ltd.

KNOXVILLE
Buford Bros.
903 General Bldg.

LOS ANGELES
Pershing Sq. Bldg.

MINNEAPOLIS
619 Foshay Tower

NASHVILLE
Buford Bros.
154 Second Ave., No.

NEW ORLEANS
Woodward-Wight & Co.

NEW YORK
39 Cortlandt St.

PHILADELPHIA
220 South 16th St.

PITTSBURGH
912 Fulton Bldg.

SAN FRANCISCO
Herberts-Moore Machy. Co.
550 Fifth St.

SEATTLE
2434 First Ave., S.

ST. LOUIS
1596 Arcade Bldg.

TOLEDO
1922 Linwood Ave.

WASHINGTON, D. C.
820 Woodward Bldg.

"Buffalo" SELF PRIMING PUMPS

Buffalo Pumps, Inc.
Buffalo, New York

Gentlemen:
Kindly send me engineering data pertaining to "Buffalo" Self-Priming Pumps.

Name .....

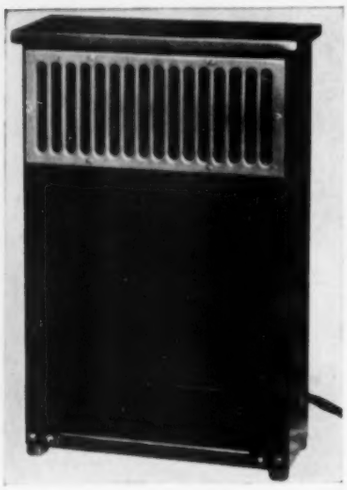
Company .....

Position .....

Address .....

Electric Convection Heater

No. 205—"Electromode" convection heater is a ¾ kw unit which utilizes the natural rise of warm air for circulation; adaptable as a source of auxiliary heat in office rooms, as a temperature booster in hard-to-heat rooms, etc.

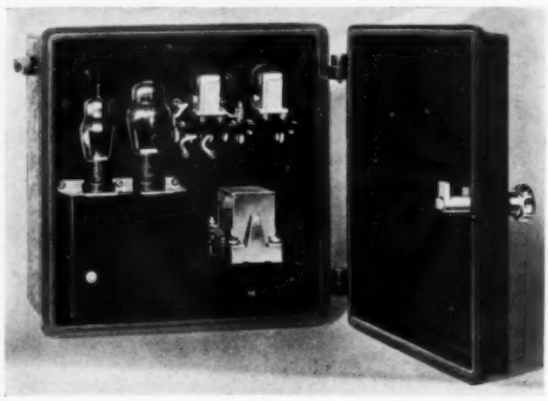


The element used is of cast aluminum construction. Heating is done by means of a calrod, around which the aluminum is poured. Shrinking of the metal in cooling causes the calrod to become an integral part of the heating element and eliminates hot wires and dead air space. Unit is compact in size, being 4½ in. wide, 9½ in. long and 16 in. high. It is completely insulated throughout so that it may be placed flush with the wall. Electric Air Heater Co., Division of American Foundry Equipment Co., 555 Byrkit St., Mishawaka, Ind.

Combustion Safeguard System

No. 206—Improved line of "Protectoglo" equipment includes two separate and distinct types of relays, and a flame sensitive electrode which can also be used as a special spark plug for electric ignition. Any of the standard line of primary controllers and motor valves are used to complete this system of combustion safeguard.

The electrical conductivity of the flame itself is utilized. The relays contain the thermionic tubes for rectification and amplification of the power input which, when conducted from the electrode unit to ground through the flame, operates the relay units controlling the operation sequence, main fuel valve, etc.

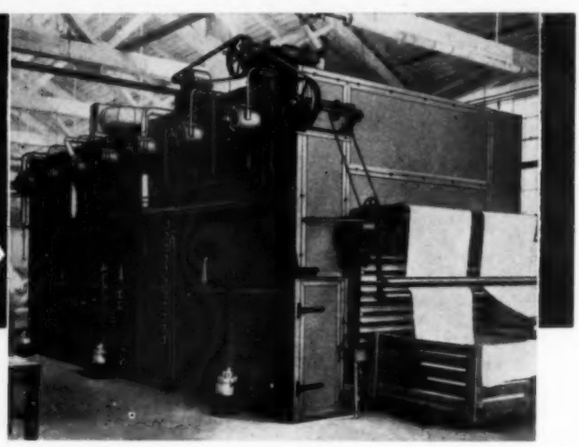


Obviously any interruption in the circuit to ground through the flame (flame failure) causes instantaneous and positive shutdown.

Features of the system are:

1 Standard radio type vacuum tubes are used, assuring long tube life.
2 The vacuum tubes are located in the relay case where they are well protected and under lock and key.
3 The relay can be located in any remote location with reference to the electrode unit.
4 The relays are housed in a rugged cast iron case.

For DRYING PROBLEMS LIKE THIS→



No matter what the drying problem is, whether it be an application that requires a large dryer such as is manufactured by the Proctor & Schwartz Company, or whether it is an application of coil and duct work built up in the Plant, TRANE Engineers can help you solve it. TRANE Blast Coils are manufactured in a complete range of sizes for both high and low pressure steam. Send us your specifications for complete engineering service.

Above is shown the new Proctor Multipass Air-Lay Dryer manufactured by the Proctor & Schwartz Company of Philadelphia, Pennsylvania. This dryer is equipped with TRANE High Pressure Coils.

Ask Trane first

————About all industrial heating, drying, and air conditioning problems. TRANE Engineering Service is at your disposal. The TRANE Company manufacturers a complete line of Unit Heaters, Air Conditioning Equipment, Product Coolers, Pumps, and Heating Specialties.

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CARBONDALE AIR CONDITIONING

for
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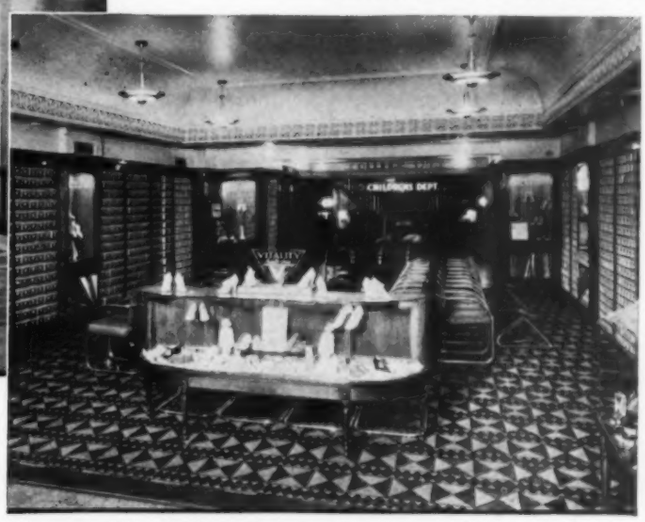
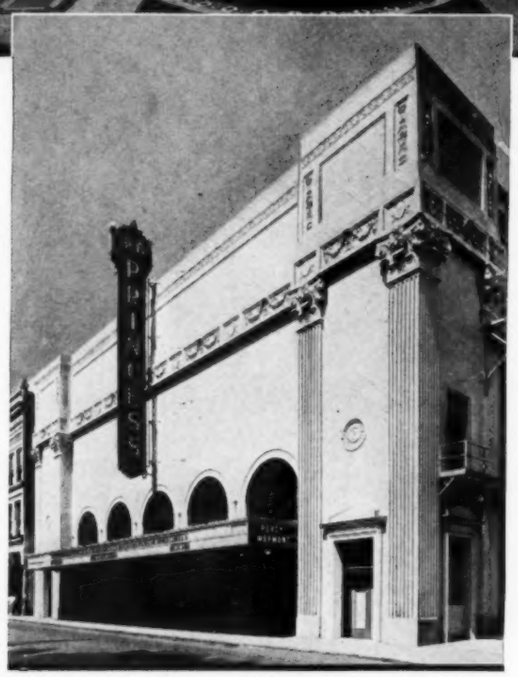
OFFICES
STORES
THEATRES
. . . wherever human comfort means better business



Wagoner-Marsh Shoe Corporation, Akron, Ohio . . . Carbondale Freon Air Conditioning Equipment serves two floors

Upper photograph shows the Williamsburg Savings Bank, New York City . . . served by Carbondale Equipment



New Princess Theatre, Honolulu . . . cooled by a Carbondale Ammonia System

THE recognition which Carbondale has won in the air conditioning field is based squarely upon a record of successful installations.

In working out a solution of *your* air conditioning problems, the Carbondale experience and the services of the engineers responsible for Carbondale performance are available without placing you under obligation.

CARBONDALE

CARBONDALE MACHINE CORPORATION
UNIT OF WORTHINGTON PUMP AND MACHINERY CORPORATION
General Offices: HARRISON, NEW JERSEY

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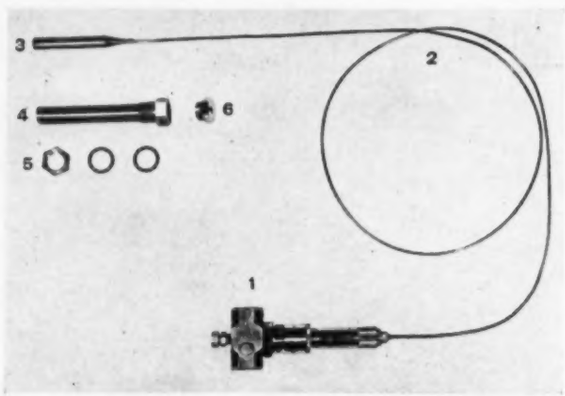
AH-3690

5 A rubber gasket is used on the hinged relay cover, making the case dust- and moisture-proof.
6 Combination door handle and built-in key lock and relay cases.
7 The terminal board is located in a separate moisture-proof chamber in the relay case.
8 Electrode unit contains no moving parts and is of a very rugged design.

This system of combustion safeguard can be supplied for practically any type of burner equipment, says the maker.—Brown Instrument Co., Div. of Minneapolis-Honeywell Regulator Co., Wayne & Roberts Aves., Philadelphia, Pa.

Automatic Steam Control Valve

No. 207—New "Yarway" automatic steam control valve is designed for connection to the outlet or condensate end of steam



heating coils in water heaters and in various types of industrial process equipment, such as dye vats, wax kettles, etc., in which close regulation of temperature is required. When so connected, this valve eliminates steam regulators and traps and frequently does away with pressure reducing valves, states the maker; may also be used on inlet end of coil.

Valve *1* is throttling type operated by thermostatic element *2* of bulb and bellows design. Temperature adjusting sleeve covering bellows end of thermostat is screwed in for lower temperatures, out for higher. Choke screw on end of valve is adjusted to suit normal condensate flow. Plug on side permits check on operation. After initial adjustments for temperature and flow, the control is automatic, opening to discharge condensate when temperature of liquid falls below point desired and closing when sufficient steam has been admitted to heating coil to re-establish operating temperature.

Thermostat bulb *3* may be clamped to outside of heater shell but usually is inserted in sleeve *4* which projects into water space in tank. The sleeve is screwed into ½ in. connection on tank wall or fastened in place by lock nut and lead washers *5*. Bulb is locked into sleeve by split nut *6*.

Valve body is of cold rolled steel, disc and seat of stainless steel, stem of tobin bronze and bonnet of brass. Valve shown is ½ in. size, suitable for steam pressures up to 125 lb.—Yarnall-Waring Co., 102 E. Mermaid Lane, Chestnut Hill, Philadelphia, Pa.

Measuring Flow of Viscous and Semi-Opaque Liquids

No. 208—Frequently flow indicators of the "Rotameter" type must be used for handling fluids which become very viscous at or near room temperature and which, in some cases, solidify altogether unless maintained at elevated temperatures. The left view on page 114 shows a "Rotameter" arranged so that the fluid can easily be held at the required elevated temperature.

A hollow pole is placed in the center of the metering tube and the rotor revolves around it; steam or hot water is passed

Before You Specify or Purchase Pipe Hangers, Pipe Clamps and Clips

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THIS NEW CATALOG of Globe Pressed Steel Installation Supplies is of special interest to everyone installing Plumbing, Heating, Air Conditioning and Sprinkler Systems. Globe Parts insure greater strength, durability, lighter weight and better appearance at LOWER COSTS than many others designed for the same uses. All Globe Parts are approved by the National Board of Fire Underwriters.

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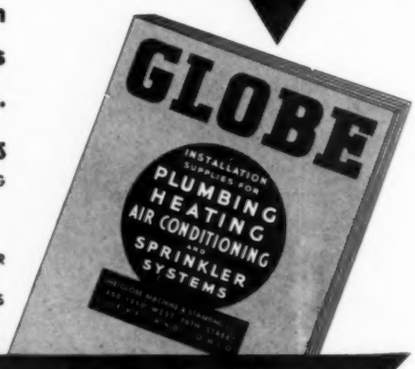
PIPE HANGERS
ADJUSTABLE SWIVEL HANGERS
SPLIT RING (CLEVIS) HANGERS
I BEAM CLAMPS
RETAINING CLIPS
UNDERGROUND HANGER CLAMPS
STEEL PIPE CLIPS
STEEL FLOOR AND CEILING PLATES
CEILING BUTTONS
STEEL INSERTS
ESCUTCHEON PLATES FOR SPRINKLER HEADS
SPRINKLER HEAD CABINETS
ADJUSTABLE CLIP BASES



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TRIMO

THE PIPE WRENCH THAT WORKS AS A UNIT

New TRIMO ALLOY PIPE WRENCH
MADE ENTIRELY OF HEAT TREATED CHROME-MOLYBDENUM MANGANESE & NICKEL STEEL ALLOYS

Look for the Red Tag always attached to Trimo

AND GIVES YOU FAST, RHYTHMIC RATCHET ACTION

• Flexibility is only possible with a Swinging Frame. Trimo has a swinging frame design and double acting spiral spring making it possible for jaw and frame to work as a unit.

And because this is possible, Trimo has 3/32 of an inch added flexibility — an instantaneous bite and a quick release.

In other words, TRIMO gives you swift, sure, rhythmic ratchet action. It is the smoothest, fastest and safest pipe wrench sold anywhere.

TRIMONT MFG. CO., INC.
ROXBURY (BOSTON), MASS.

MADE THROUGHOUT OF CHROME MOLYBDENUM STEEL — HANDLE DROP FORGED — NOT CAST

TRICROME CUTTER WHEELS
Thin blade special analysis steel—silvered to resist rust. Identified by red hub.

TRIMO CHAIN WRENCH
Replaceable parts, quality steel make this giant chain wrench safest and most serviceable.

TRIMO PIPE CUTTERS
Trimo, Barnes and Saunders type.

Your Guarantee

This is an invitation to YOU to adopt "K" cast iron fittings, if you have not already done so. So order some "K" 's for the next job, do some comparing and learn that different makes of fittings vary tremendously *in analysis—in design, smoothness of casting, way they're threaded—way they make up.*

Complete line *Quantity production*
Heavy inventories for quick shipment
No job too big *No delivery speed too fast*

Standard and extra heavy screwed fittings—American sprinkler fittings—standard flanged fittings—standard and extra heavy companion flanged fittings—AND DRAINAGE FITTINGS.

All fittings hand inspected. Extra heavy screwed American Sprinkler and flanged fittings hydrostatically tested to 300 lbs.

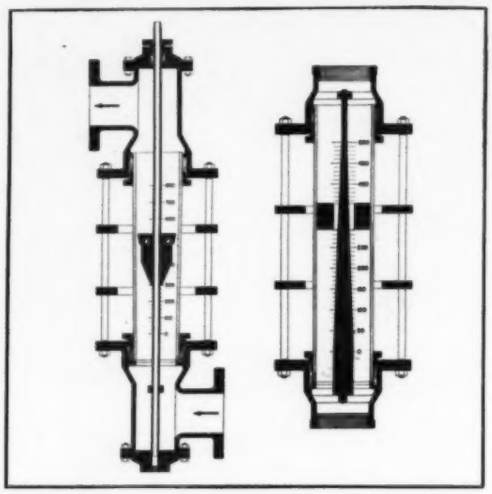
CATALOG TO PLUMBERS AND INDUSTRIAL USERS UPON REQUEST

KUHNS BROS. CO.
DAYTON, OHIO
U. S. A.
EST. 1887

Important
Combined marketing facilities on both "K" cast-iron fittings and M. I. F. malleables. Complete stocks at both Dayton, Ohio, and Branford, Connecticut.

into the hollow space through suitable connections in the top and bottom covers.

With this construction, the heat is efficiently used since it is applied in rather than around the fluid to be heated and good heat transfer is obtained, says the maker. To prevent heat loss



to the outside of the metering tube, a protection box can be placed around the instrument to provide a dead air space.

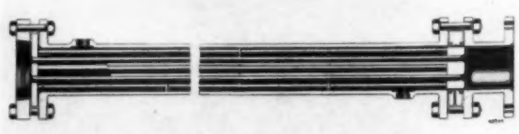
When oils and similar semi-opaque liquids must be metered, the standard tapered tube "Rotameter" is sometimes not completely satisfactory due to the difficulty of seeing the rotor through the layer of liquid between the tube and the rotor. For such service a special indicator has been developed as illustrated in the right hand view. In place of a tapered glass metering tube a straight cylindrical tube is used and inside it is a tapered pole. The pole has its larger end at the bottom and the rotor fills the space between the tube and the larger end of the pole with only slight clearance. Flow of the semi-opaque fluid pushes the rotor upward in the normal manner but creates a free space between rotor and pole rather than between rotor and tube.

Since the film of liquid between the rotor and the tube is quite thin, the rotor can be seen without difficulty. Thus, this type will handle successfully any dark liquid of which a thin film will be translucent, including the majority of liquids usually considered opaque.—Schutte & Koerting Co., 12th and Thompson Sts., Philadelphia, Pa.

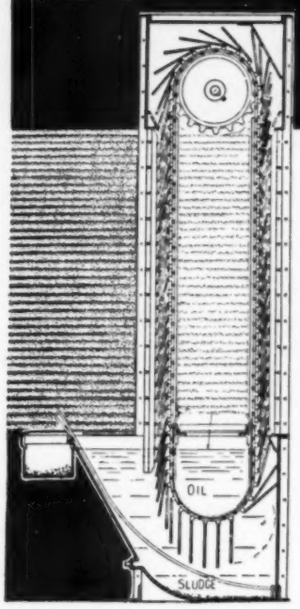
Pipe Line Aftercooler

No. 209—Aftercooler of new design is designed to serve air and gas compressors of moderate capacities. It is used in the discharge line in place of a section of the pipe, thereby making discharge pipe and aftercooler a complete unit.

The compressed air or gas passes through a large number of tubes, and is broken into thin streams so as to furnish maximum

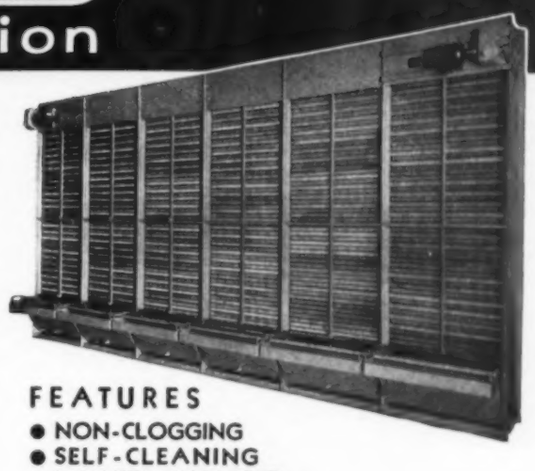


cooling surface. The cooling water enters at the point of lowest air temperature and flows counter to the flow of air, spaced bakelite baffles guiding the cooling water across the muntz metal air tubes. At the end of the "PL" cooler, the velocity of the compressed air is reduced in a moisture separating chamber which reverses air flow several times and traps out condensed moisture. Condensate is removed from the air path and cannot be again picked up. Cooler can be mounted in any position.—Ingersoll-Rand, 11 Broadway, New York, N. Y.



DOUBLE DUTY
Air Filtration

A heavy-duty air filter scientifically engineered to do its work automatically and maintenance free. The "DOUBLE DUTY" air filter is of all steel construction and operates on the principle of true impingement. "DOUBLE DUTY" superiority has been thoroly proven thru years of service in varied types of public, commercial, educational and miscellaneous industrial buildings — steel mills, automotive plants, etc. Write for further particulars.



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- SELF-CLEANING
- MAINTENANCE FREE
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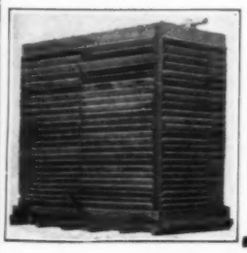
"INDEPENDENT"

INDEPENDENT AIR FILTER COMPANY
215 WEST OHIO STREET, CHICAGO, ILLINOIS



A TYPE FOR EVERY AIR CONDITIONING INSTALLATION

No matter how large or how small your air conditioning installation may be, there is a Marley water cooling system for it. From the small series, all steel indoor tower for small jobs on up to the largest forced draft installation, Marley can supply your requirements.

And—Marley water cooling systems are easier to sell because seven years of national advertising has acquainted buyers with their outstanding advantages.

Write for complete details on the entire Marley line.

THE MARLEY COMPANY
1915 Walnut Kansas City, Mo.

MARLEY
WATER COOLING SYSTEMS

EQUIPPED WITH MARLEY PATENTED SPRAY NOZZLES
Marley nozzles lead the field in sales because they give more efficient, more economical service in any type of water cooling system.

Sound Level Indicator

No. 210—Sound level indicator recently announced is designed to measure sound levels exactly as heard by the human ear. With it the user can quickly secure accurate data on sound and noise levels.

The indicator consists of a calibrated crystal type microphone, an audio frequency amplifier with all metal tubes, a calibrated attenuator, an ear weighing network, a decibel meter and a crystal type headset. The range is from 30 to 90 decibels. Although designed for a-c operation, batteries may be used—Industrial Apparatus Co., 720 N. Wabash Ave., Chicago, Ill.

Hot Jaw Pliers for Making Solder Joints

No. 211—New "Thermo-Grip" hot jaw pliers have been developed for applying heat for making sweated joints with solder

type copper pipe and fittings, and for other miscellaneous soldering applications. To make a joint, the pipe, tube, or fitting is cleaned, flux applied, fitting slipped over end of pipe and the jaws of the pliers are clamped lightly on the outside of the fitting where the heat is required.

Plugged into a standard 110 volt a-c outlet, the transformer, which is part of the complete unit, converts the current to low voltage, high amperage current and carbon blocks in the jaws apply the heat. Furnished with 10 ft rubber covered cord with rubber plug, on-off and high-low switch, the pliers are of cast bronze with fiber heat insulating handles. Standard unit is 110 volt, 50-60 cycle; 110 volt, 25 cycle unit available at slight additional cost.—Ideal Commutator Dresser Co., 1537 Park Ave., Sycamore, Ill.

New Automatic Impingement Type Filter

No. 212—New automatic impingement type air filter provides four successive stages of filtration in the form of two endless curtains, arranged to rotate in such manner that the face of the curtain, on the dirty air side, will be thoroughly cleaned before returning to the clean air side. First stage collects the heavier dust, serves to break up the air flow into small streams causing it to assume intimate contacts with the adhesive surface. It then travels downward into the oil bath, where all parts of the media are immersed for about 1½ hr. Leaving the bath, it becomes the second stage after passing a compressed air line from which air is blown through the medium to remove surplus oil. Moving upward, it entraps any fine dust particles.

The third stage collects any residue of oil that may have a tendency to entrain in the air flow; it proceeds downward but does not pass through the oil bath, cleaning being accomplished by a second compressed air line. After passing over this, it becomes the fourth stage, preventing still further oil entrainment and passage of fine dust particles. The third and fourth stages operate in a comparatively dry state.

Framework is of rugged construction; filter curtain consists of panels of wire cloth to which is attached successive layers of knitted copper mesh; drive is 1/6 hp capacitor motor operating

SUMMER—THERMOSTAT—WINTER

One temperature controller for two seasons—air conditioning. One turn of switch and your air conditioning system is set for the up swing of summer temperature. One turn again and it is set for the down swing of winter temperature.

May we ask—is it easier to buy and install an additional thermostat?

—or just turn a switch. It's the economical way. One Summer-Winter Thermostat at slight cost above the old-fashioned One-Season Thermostat. It's the modern progressive way.

JULIEN P. FRIEZ & SONS, Inc.

"The Makers of America's Weather Instruments"

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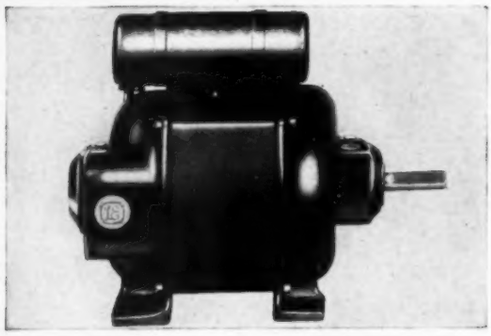
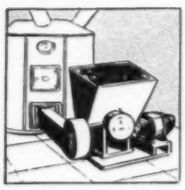
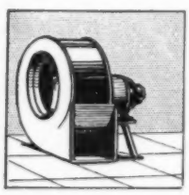
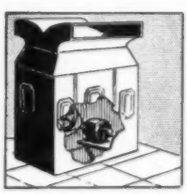


LELAND CONDENSER TYPE







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The enviable reputation of the Leland motor in the appliance field can be turned to your advantage, not only as an efficient drive but as an effective appliance "salesman."

Power your air conditioner with a Leland split phase, your oil burner wth a Leland split phase, or your water circulator with a Leland condenser motor and you have the ideal combination. Or perhaps it is a stoker and a Leland repulsion-induction unit will serve you best. "Draft a Leland to help you sell it."

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LELAND MOTORS

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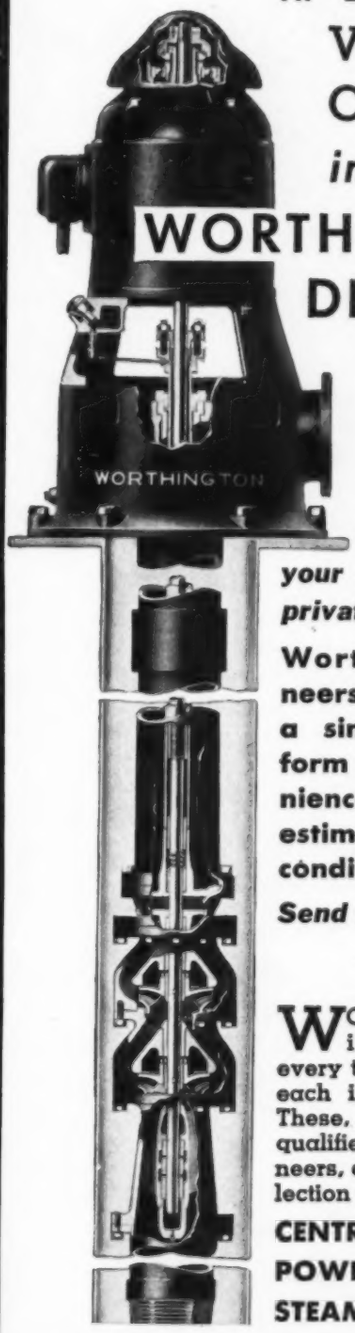

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WORTHINGTON

at 1725 rpm through 400-1 reduction unit, with further reduction of 3-1 through chain drive. Control is automatic, consists of timing device operated by telechron motor, adjustment dial, magnetic switch, etc.

Cleaning efficiency is 97 to 98 per cent, states the manufacturer,

and average operating resistance is 0.35 W.G.—Staynew Filter Corp., 25 Leighton Ave., Rochester, N. Y.

Line Voltage Thermostat for Air Conditioning, Heating

No. 213—New electric room thermostat has been developed particularly for control of air conditioning, unit coolers and unit heaters. Design is novel in that it utilizes a liquid expansion thermostatic system with a sensitive air bulb coiled under the perforated case, said to make for rapid response to temperature change and minimizing time lag. Differential can be made as little as ½ F, states the manufacturer, but can be increased where desirable. Standard range is 20 to 90 F.

Same instrument also available with bulb extending from back

of case for use as ductstat or aquastat. All are of line voltage type, and can handle a-c loads up to 1000 watts or ½ hp motor without need for a relay or transformer.—Wilbin Instrument Corp., 40 E. 34th St., New York, N. Y.

Small-Bulb Gas-Filled Thermometer

No. 214—An accurate gas-filled recording thermometer, having a small temperature-sensitive bulb for long lengths of connecting tubing, has been developed and is offered for measuring temperatures between —60 F and 1000 F, where tubing lengths as long as 100 ft, and even longer under certain conditions, are required by the application. It is fully compensated,

Jointite TRADE MARK CORK INSULATION
FOR AIR CONDITIONING

The surest way to obtain economical temperature control is to use good cork insulation. "Jointite" Insulation is pure Cork of the finest grade, fabricated by the Mundet process into Corkboard and Moulded Cork Pipe Covering. These products offer the air conditioning industry the same high quality and low transmission coefficient per inch of thickness that have won universal acceptance for Mundet Cork Products. Write for a copy of our Catalog, or refer to Sweet's Architectural Catalog.

Mundet Natural Cork Isolation Mats solve the problem of machine vibration.

MUNDET CORK CORPORATION
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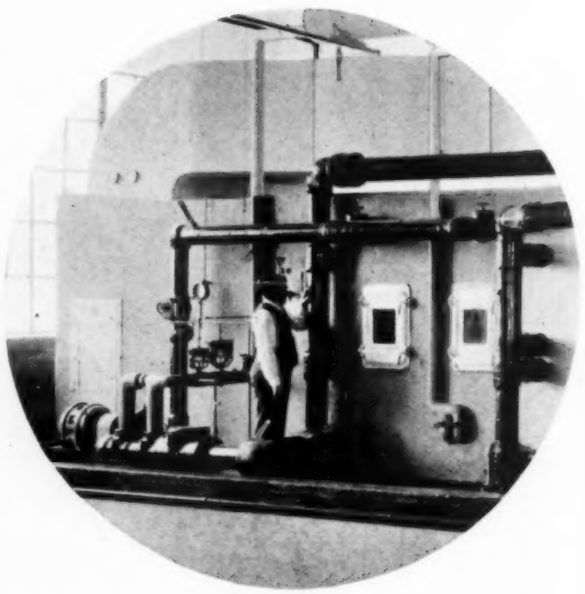


In the Brooklyn plant of the New York Daily News, all cold lines and ducts in the Air Conditioning system are insulated with "Jointite" Cork Pipe Covering and Corkboard.

Photo: H. Armstrong Roberts

Constantly Controlled Direction

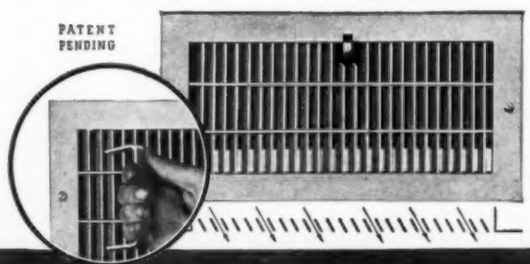
The navigator of today, with the aid of modern instruments and controls, plans and directs his course with accuracy undreamed of in the old days.

The air conditioning engineer, too, with Independent "Fabrikated" Adjustable Directed Air Flow Registers and Grilles can plan and direct air flows with accuracy which was only a hope two years ago.

Registers and grilles are installed. Conditions may change; or perhaps they have not been fully anticipated. No matter. When Independent "Fabrikated" Adjustable Directed Air Flow Registers and Grilles are used, the grille bars can be turned to any desired angle up to 45 degrees, right or left, or up or down, until the desired air flows are attained.

Send for catalog and data book

THE INDEPENDENT REGISTER CO.
3757 EAST 93rd STREET CLEVELAND, OHIO



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You will benefit directly from more than half a century of experience when you specify "Devlin" on your orders for fittings and nipples.

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Whether your piping problem is water, oil, steam, or gas, you will find Devlin Fittings and Fretz Nipples to be thoroughly DEPENDABLE.

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This dependability guarantees installations easily and quickly made, and with less waste of material. And it means installations which don't spring leaks after the pressure is turned on.

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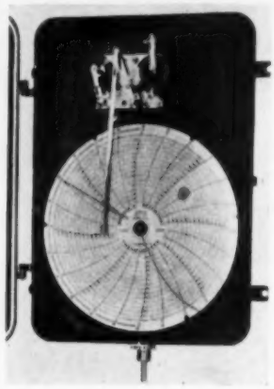
being so designed that temperature changes in the case of the instrument and along the tubing are corrected for, independently, by means of a compensating device. This device eliminates the necessity of long bulbs on thermometers having tubing lengths over 25 ft.

The thermometer consists of a rectangular case in which there are mounted two measuring elements, connected through a compensating mechanism. Two capillary tubes, filled with the same



gas, run from each element through one armor tube to the sensitive portion of the bulb. Only one capillary tube is connected to the temperature-sensitive bulb. The other is closed at the bulb end. Both capillary tubes, being adjacent, are subjected to the same temperature changes. Through the compensating mechanism, the tube and element not connected to the bulb correct for temperature changes along the connecting tube and in the case. In other words the tube and element not connected to the bulb produce a balancing action which offsets the effect of temperature variations along the tube and around the measuring element connected to the bulb.

These thermometers are offered with one or two pens in the 12 in. chart size; and with one pen only in the 8 in. chart size.—The Bristol Co., Waterbury, Conn.

Direct Air Heaters

No. 215. Manufacturing rights have been taken over by the Nelson Co. to manufacture "Bertossa" power heaters and allied air conditioning equipment. These heaters are now available

in eight sizes with capacities ranging from 80,000 to 2,800,000 Btu. Illustration shows a unit fired by oil installed in a factory and rated at 1,900,000 Btu at the bonnet.—Nelson Co., 2604 Fourth Ave., Detroit, Mich.

TRADE FRICK MARK
Refrigeration
Cools more than 50,000 cubic feet of air per minute for air conditioning the magnificent 10-story office building of the National Reserve Life Insurance Co. at Topeka, Kan. The three Frick Freon Compressors illustrated carry the 131-ton refrigerating load.
Let the nearest Frick Sales-Engineer give you the full facts and figures on Frick Refrigeration, whether for air conditioning, cooling drinking water, food service, freezing ice, process work, etc. Write today.
DEPENDABLE REFRIGERATION SINCE 1882
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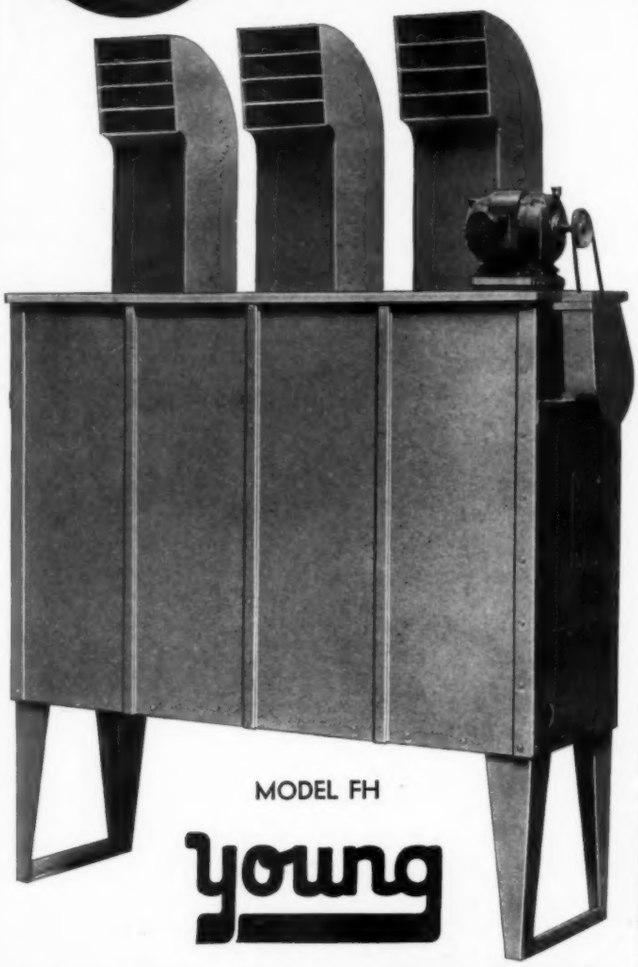

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UNIT HEATERS

with or without Thermadjust controls

Young Model FH Unit Heaters are designed to combine all of the latest developments in heat transfer and air delivery and offer many desired economies—Low installation cost, Low operating costs, Zone temperature control, Forced air circulation.

They are available in ten sizes designed for floor mounting, vertical wall mounting, or horizontal ceiling suspension—capacities range from 191,000 to 802,000 BTU per hour.

WRITE FOR IT—Catalog 336 gives complete description, illustrations and technical information concerning this new line. There is no cost or obligation.

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RACINE, WISCONSIN

Young Quality

YMCA

Triangular insignia of the Young Men's Christian Association, representing "Spirit, Mind and Body."

THREE YMCA BUILDINGS REDUCE HEATING COSTS

Webster Heating Modernization Cuts Fuel Bills Without Impairing Heating Comfort

CINCINNATI "Y" SAVES $1,486

Cincinnati, O.—Three large Young Men's Christian Association buildings report sharp reductions in heating expense as the result of Webster Heating Modernization Programs completed within the last few years.

In downtown Cincinnati, the Association building saved 357 tons of coal within two years after the new heating system was installed. This is a cash saving of $1,486.

In neighboring Columbus, and in Minneapolis, Y. M. C. A. Buildings have achieved similar heating economies, without sacrificing heating comfort, by installing the Webster Moderator System of Steam Heating.

During the first two years in the Columbus "Y," the Webster Moderator System reduced coal consumption 395 tons. This is a cash saving of $1,294. Savings in this case, as at Cincinnati, are based on the difference between current coal bills and past average coal bills over a two or three-year period.

Cafeterias, auditoriums, class and club rooms, handball courts, garages, swimming pools, gymnasiums—every heating need of Association buildings is adequately met in these three installations. The distribution of steam is balanced so that all radiators heat evenly and rapidly.

The savings in heating expense are now available to these three Associations for carrying out a well-rounded program of Y. M. C. A. activities.

Marshall Murray, chief engineer and building superintendent of the Columbus Y. M. C. A., expresses complete satisfaction with the performance of the Webster Moderator System.

"The building has been comfortably heated at all times," Mr. Murray said. "There are no cold corner rooms. The warm-up period has been considerably shortened and even during the severest weather the system has met every demand made upon it."

Y.M.C.A. Central Bldg. Minneapolis, Minn.

Y.M.C.A. Central Parkway Branch Cincinnati, Ohio

Y.M.C.A. Building Columbus, Ohio

If you are interested in heating *new* buildings, or in improved heating service and lower heating cost in your present building, address

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Booklets, Reports and Papers

Welding Brass and Bronze

An illustrated 12-page booklet on the oxy-acetylene welding of brass and bronze has recently been published.

There are two main sections to the booklet, the first devoted to the technique of fusion welding brass and bronze. The booklet also contains an illustrated section on the welding of commercial yellow brass pipe. Joint design and welding technique are discussed in detail. Three tables give data on welding time, material consumption, and tensile strength of welds made in various positions.

It is available on request through The Linde Air Products Co., 30 E. 42nd St., New York, N. Y.

Conditioning Paper for Printing

Research Paper RP859 of the National Bureau of Standards, entitled "Treatment of Offset Papers for Optimum Register," by Charles G. Weber and Martin N. V. Geib, describes a study made of the relation of the hygrometric condition of papers at the start of the first print to changes in moisture content during printing, and to the register of prints.

It was found possible to maintain constant dimensions by two methods of conditioning. Papers conditioned first at a very high relative humidity, then to equilibrium with the press room atmosphere by desorption, remained fairly constant. Also, papers prepared for printing by conditioning to equilibrium with relative humidity 5 to 8 per cent above the press room condition gave very satisfactory results, the latter procedure being considered more feasible for commercial practice.

Copies of this 11-page report are available from the Superintendent of Documents, Washington, D. C., for 5c.

Report Summarizes Activities of Construction Industry

Recent developments in construction are presented in a survey, "The Construction Industry," made public by the Department of Commerce. The report combines an analytical discussion of the construction industry with a practical handbook or guide to the industry as represented by its leading trade associations. It was found that approximately 600 trade associations of national or interstate scope are now organized in the building and allied industries; the name and address of each is given.

The study presents a picture of construction activities in the United States, and a running summary of trends in recent years for the various fields of construction, including commercial, industrial and residential buildings, road construction, and the programs of governmental and public utility agencies. It also contains a summary of 1935-1936 projects and plans of the federal government in power and irrigation dam construction.

Estimates from both private and public sources are included. They show that this industry, averaging over 12 billion dollars annually during the 1926-1928 period, fell to less than one-third of that amount in 1933. Data are presented showing the increases since then, into early 1936. Estimates are included on the volume of construction in 17 fields. Statistics with textual comments cover the manufacturing, wholesaling and retailing of building materials, and the number of employees in job-site construction.

Journals in construction or allied lines and many private research bureaus are listed, with addresses. A brief summary is given of each of the agencies of the federal government now assisting in the rehabilitation of the construction industry.

This 123-page study, including 37 pages of charts, maps, and tables, may be obtained for 10 cents from the Bureau of Foreign and Domestic Commerce in Washington, D. C., or any of its district offices in larger cities throughout the United States.

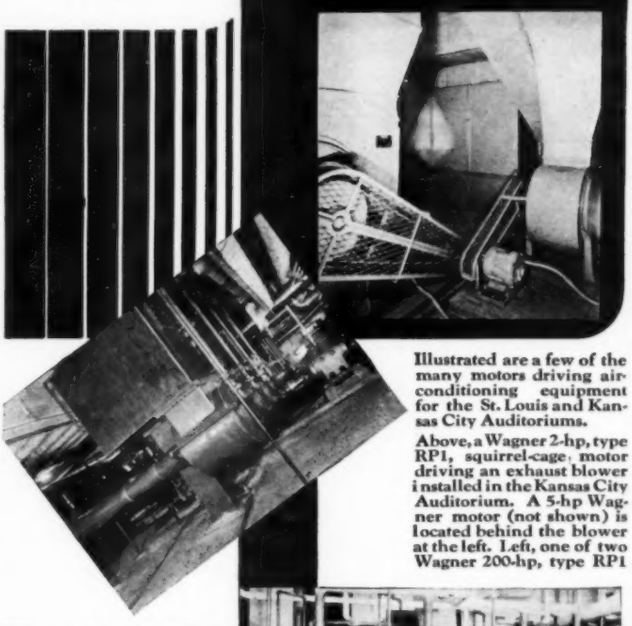
● This is one of a series of three banana ripening rooms installed with Baker automatic cooling, heating, ventilating, and humidifying equipment. Engineers who select Baker Air Conditioning "know their bananas" about perfect ripening of fruits in storage for distribution without loss.

BAKER ICE MACHINE CO., INC., 1509 Evans, Omaha, Nebr.

WAGNER MOTORS MEET

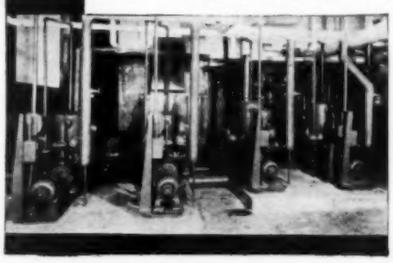
for the ST. LOUIS and KANSAS CITY Auditorium Air-Conditioning Installations

the requirements of performance and dependability



Illustrated are a few of the many motors driving air-conditioning equipment for the St. Louis and Kansas City Auditoriums.

Above, a Wagner 2-hp, type RP1, squirrel-cage motor driving an exhaust blower installed in the Kansas City Auditorium. A 5-hp Wagner motor (not shown) is located behind the blower at the left. Left, one of two Wagner 200-hp, type RP1 870-rpm, 440 volts, squirrel-cage motors driving chilled water pumps for the air-conditioning system of the St. Louis Auditorium.



Right, Wagner type RP1 squirrel-cage motors driving pumps used in connection with the air-conditioning system of the Kansas City Auditorium. The motors in the left foreground are 2-hp ratings — those at the right are 3-hp ratings.

Dependable, economical and efficient operation of any air-conditioning installation depends largely upon the reliability and performance of the electric motors that drive the equipment. Consequently, manufacturers and contractors who recognize the value of dependable and sturdy motors for their air conditioning installations specify Wagner motors, because they are particularly suited for this type of service. They know that Wagner motors have been perfected after many years of experience and are specially adapted for driving air-conditioning equipment, and therefore will give dependable, economical and efficient service.

On your next air conditioning design or installation problem — consult Wagner. Wagner's experience will be helpful to you. Send for descriptive literature today.

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6400 Plymouth Avenue, Saint Louis, U.S.A.

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THE AVERAGE LAYMAN, looking at a refrigeration installation is likely to be thoroughly impressed with its complexity and appearance, even though it may be operating with a considerable loss in refrigeration.

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THE SUCCESSFUL BUSINESS MAN, intensely interested in the efficiency of his installation, guards against refrigeration losses by watching the cost sheet closely. Costs can be lowered by USING THE MOST EFFICIENT INSULATING MATERIAL AVAILABLE.

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The Editor's Correspondence

Improving Office Air Conditions

THE EDITOR.—In an office building 120 ft x 60 ft x 15 ft, with windows on all sides (storm sash in cold weather) the employees complain of poor ventilation and generally dry, dusty, and unsatisfactory air conditions. Several private offices are arranged with 8 ft high glass partitions and there are partitioned spaces for wash rooms, records, etc., but in general the main office is one large space with 15 ft ceiling height. Direct steam radiators with pneumatic temperature control valves heat the entire building, and ventilation air is introduced through about 20 ceiling grilles with horizontal deflecting pans suspended beneath them. About 3000 cfm of fresh air is mixed with about 2000 cfm recirculated from a baseboard grille at one end. The private offices have door grilles near the floor. No filtering or cleaning is provided and the outdoor atmosphere is often dirty due to railroad and river traffic nearby. Three banks of heat surface sections with separate steam control temper the air which is introduced at about 85 F.

There are only about 50 persons in the office, and it would seem that except for air cleaning and humidification the ventilation problem is a simple one. We believe that the 3000 cfm of fresh air is ample, but that more should be recirculated, and that more return air intakes would help, particularly in the private office spaces.—E. M. B.

REPLY.—The need of air cleaning devices is outstanding, since the outdoor air is heavily soot-laden and the recirculated air carries dust from the floors, clothing, etc.

The distribution of the air is faulty, since with overhead pan type air supply the entering air during occupancy should be slightly cooler than the room air at the inlet zone, so that the entering air may fall down to the occupied zone in a gentle manner without drafts. If the entering air is warmer than the room air it will stay up above the occupied zone until the feeling of freshness which it is intended to create has been lost.

The lack of any means of introducing moisture is noticed, and extreme dryness can be expected, especially with the excessive temperatures reported. It is not stated whether there is any exhaust fan to remove the 3000 cfm of waste air which must go somewhere if 3000 cfm of new air constantly are being introduced.

I would do the following things:

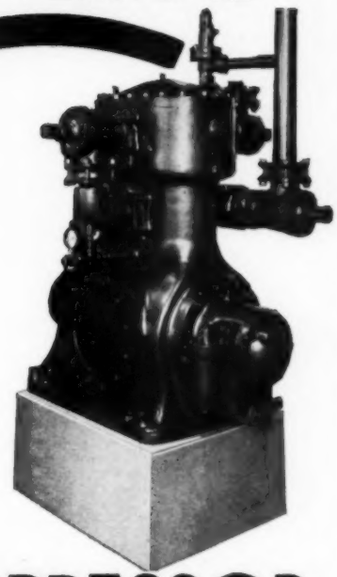
1. Insure adequate removal of the contaminated air.
2. Reduce the inlet air temperature to 68 F or even cooler, compelling the direct radiators to carry the main heat transmitting burden.
3. Install air filters of the oil-impregnated type preferably on the leeward side of the tempering heaters but acceptably on the windward side.
4. Reduce rather than increase the volume of air circulated, and reduce rather than increase the volume of outside air, since with adequate air temperature adjustment it is practicable to remove the excess heat and moisture from 50 people with a total air circulation of not exceeding 2000 cfm.
5. Increase the return circulation or exhaust facilities by removing part of the air from a grille near the ceiling, since with proper control of the entering air this will fall down into the breathing zone and the warmer air from that zone will be displaced upward, ready to be removed through this new, added outlet.
6. Install a humidifier of the open tank type, having a submerged steam heating coil and a float controlled water supply. The controlling instrument can be placed in the return air duct and should operate a valve on the steam supply to the submerged coil. The tank of course must be placed on the leeward side of the tempering heaters.

Clark-Sundh

Clark-Sundh Automatic Control Equipment is handling the Motors for the Cooling Tower installation in the St. Louis Municipal Auditorium. Twenty-One Controllers ranging from 3 H.P. to 200 H.P. are included in this installation.

THE CLARK CONTROLLER CO. 1146 E. 152ND ST. CLEVELAND, O.

Vilter VERTICAL COMPRESSOR



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The Vilter "Freon" Compressor is designed to meet industrial applications where "Freon" is used as the refrigerant. It commends itself especially for installations where human comfort or the preservation of perishables demand the utmost protection.

In its building, the Vilter "Freon" Compressor reveals principles and practices which are old to Vilter, whose long years of pioneering have produced equipment which has brought air conditioning to its present high state of efficiency and safety.

Whatever your program for air conditioning, whether human comfort or processing, you can profit by investigating Vilter equipment.

F. H. A.
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THE VILTER MANUFACTURING COMPANY
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REPRESENTATIVES IN PRINCIPAL CITIES

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Photo courtesy of Wurtz Bros., N. Y. C.

ABOVE you see the new modern Kress Building, Fifth Avenue, New York. One thing this picture does not show is the efficient way Novoid Corkboard is guarding the cold air ducts and piping of the Carrier Air-Conditioning System.

Why is Novoid selected for so many important insulating jobs throughout the country? Cork, that natural barrier to heat, is the principal reason.

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Please send me complete information about Novoid Corkboard, including drawings showing method of applying to air ducts.

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7. The control of the steam supply and the bypass damper for the tempering heaters should be very efficient. The safest arrangement probably is to have a pilot thermostat in the office which controls the compressed air supply to a two stage duct type thermostat in the discharge duct from the supply fan. If the office becomes too warm the pilot thermostat passes air to the duct thermostat, which thereupon closes off one of the valves. If the office thereafter continues to be too warm the duct thermostat will close off the second valve. If the office still continues to be too warm the duct thermostat will open, very slowly, the bypass damper. However, if the result of the action of the pilot thermostat and duct thermostat causes the entering air passing the duct thermostat to be so cool as to cause drafts, say below 60 F, the duct thermostat will refuse to pass such cool air and will cause it to be heated to 65 F or so, thus militating against draft creation. There should be a duct thermostat on the windward side of the tempering heaters, controlling the steam supply valve to the first section of this heater which is touched by the entering air, and this thermostat should be adjusted so as to open the valve whenever the outside temperature is colder than, say, 34 F.—Samuel R. Lewis.*

*Consulting Engineer, Chicago, Ill. Member of Board of Consulting and Contributing Editors.

Book Reviews

Industrial Humidity Control

"Controlled Humidity in Industry", by Dr. M. C. Marsh of the Wool Industries Association. Published in London by Charles Griffin & Co., Ltd., and in the United States by J. B. Lippincott Co, Washington Square, Philadelphia, Pa. 123 *pp., 6 x 9 in., clothbound. Price,* $2.50.

Object of this book is to review the question of the control of humidity under industrial conditions, and the principles of the instruments and equipment used for the purpose, particular emphasis naturally being given to applications in the textile industry.

Following introductory chapters on the importance of humidity in industrial processes and the fundamental laws of humidity, the author presents in Chapter 3 a complete discussion of methods of measuring relative humidity, describing numerous types of wet and dry bulb thermometers, hygroscopic methods, the dew point and other methods, and related instruments such as the kata thermometer, eupatheoscope, and the "rate of drying" meter. Chapters 4 and 5 describe, respectively, methods of increasing and decreasing relative humidity, and Chapter 6 is devoted to central station air conditioning plants.

Automatic humidity controls is the subject of Chapter 7, and various types of instruments and their principles of operation are considered in some detail. Chapter 8 is a brief description of thermostats. Subject of Chapter 9 is humidity control in testing rooms and laboratories.

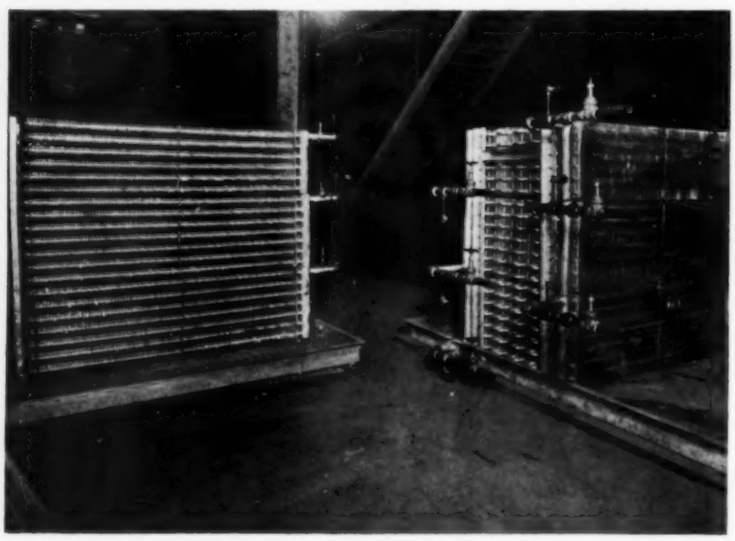
The appendix is devoted to the application of the factory and workshop acts to artificially humidified buildings.

Conventions and Expositions

Wisconsin Air Conditioning and Heating Exposition: May 12-16, Milwaukee Auditorium, Milwaukee, Wis. Manager, Norbert Beerend.

Air Conditioning Manufacturers' Association: Annual meeting: May 16, Hot Springs, Va. Headquarters Office, 915 Southern Bldg., Washington, D. C.

Refrigerating Machinery Association: Spring meeting, May



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installed with a brine system in a modern brewery. These coils have a 3¼" square fin spaced ¾" apart on 1" O. D. steel tube and are galvanized. However, there are 36 other standard combinations of fin and tube sizes and fin spacings available to meet all requirements and they can be made in all standard metals.

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NO, we don't want to sell you a mermaid—but thereby hangs a "tale." The siren in this case is not a steam whistle, nor yet a bewitching damsel—but the lure of *low-cost steam transmission.* In their anxiety to save on *first* cost, some owners and utilities are putting in, or have put in, underground lines on which the construction, drainage, and type of insulation leave little chance for the permanent economical conveyance of steam.

Ric-wiL Conduit, the correctly engineered system, will keep your steam lines tight, dry and 90% (or more) efficient. It is made in a variety of weights and designs in both Tile and Cast Iron, to secure maximum results on *any* problem of underground steam transmission for heat or power. A choice of insulations, including the famous Ric-wiL waterproof asbestos Dry-paC. Ric-wiL Systems are complete, including installation instructions and engineering service drawings—and supervision on the job if desired. Write today for Bulletin.

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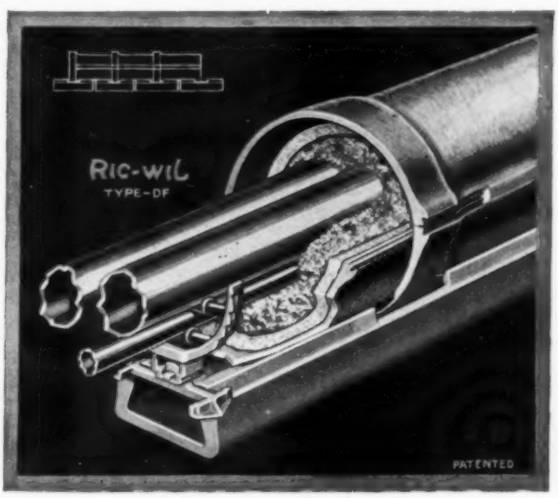
• Ric-wiL Dry-paC is pure asbestos insulation, which has certified conductivity of only .36 B. T. U. for low pressure.



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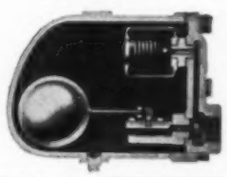

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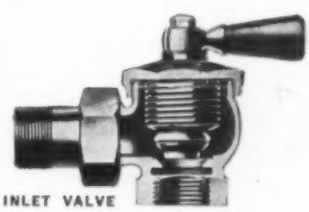

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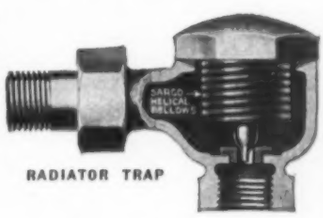

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TYPE H THERMOSTAT by GENERAL CONTROLS

This sensitive heat-accelerated instrument responds immediately to small temperature change. Lag action is eliminated, allowing for greatest furnace efficiency—lower standby and radiation losses — lower fuel consumption — more uniform room temperatures.

Like all fine instruments, the beautifully molded GENERAL TYPE H THERMOSTAT lends itself to any style of architecture.

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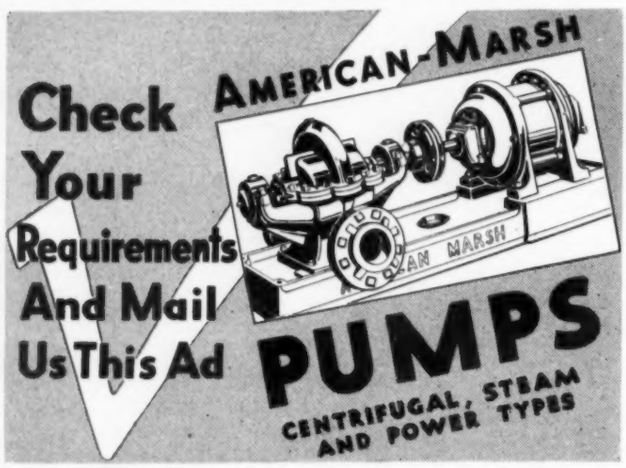

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- ☐ Sump Pumps
- ☐ Tank Pumps (Steam)
- ☐ Vacuum Heating Pumps (Centrifugal)
- ☐ Vacuum Heating Pumps (Steam)

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Heating, Piping and Air Conditioning Contractors National Association: Annual convention, May 25-27, The Bellevue-Stratford, Philadelphia, Pa. Educational Director, S. Lewis Land, 1250 Sixth Ave., New York, N. Y.

National District Heating Association: Convention and exhibit, June 16-19, Pantlind Hotel, Grand Rapids, Mich. Acting Secretary, Miss M. C. Stocker, 124 W. Fourth St., Greenville, Ohio.

National Warm Air Heating and Air Conditioning Association: Convention, June 17-18, Deshler-Wallick Hotel, Columbus, Ohio. Manager Director, A. W. Williams, 50 W. Broad St., Columbus, Ohio.

International Congress of Refrigeration: June 16-27, The Hague and Amsterdam, Holland. Organization Office, 107 Stolberglaan, The Hague (Holland).

American Society of Heating and Ventilating Engineers: Joint semi-annual meeting with *American Society of Refrigerating Engineers*, June 22-24, Buck Hill Falls, Pa. Secretary, A. V. Hutchinson, 51 Madison Ave., New York, N. Y.

Short Course in Coal Utilization: June 9-11, University of Illinois, Urbana, Ill. A. C. Callen, Head of the Department of Mining and Metallurgical Engineering, 209 Transportation Bldg., Urbana, Ill.

American Society for Testing Materials: Annual meeting, June 29-July 3, Chalfonte-Haddon Hall, Atlantic City, N. J. Assistant Secretary, R. E. Hess, 260 S. Broad St., Philadelphia, Pa.

Great Lakes Exposition: July-September, Cleveland, Ohio. General Chairman, Dudley S. Blossom, Terminal Tower, Cleveland, Ohio.

National Association of Power Engineers: Annual convention and exhibit, August 31-September 4, Hotel Stevens, Chicago, Ill. Secretary, F. W. Raven, 176 W. Adams St., Chicago, Ill.

National Power Show: November 30-December 5, Grand Central Palace, New York, N. Y. Manager, Charles F. Roth, Grand Central Palace, New York, N. Y.

American Society of Mechanical Engineers: Annual meeting, November 30-December 5, New York, N. Y. Secretary, C. E. Davies, 29 W. 39th St., New York, N. Y.

Recent Trade Literature

For your convenience in obtaining copies of bulletins, see coupon on page 134

No. 952. AIR COMPRESSORS: Allis-Chalmers Mfg. Co., Milwaukee, Wis. 4 p. bulletin on "Ro-Twin" rotary air compressors for pressures up to 100 lb, describing design, giving specifications, table of capacities and approximate dimensions.

No. 953. AIR CONDITIONING: Carrier Engineering Corp., 850 Frelinghuysen Ave., Newark, N. J. Spirally bound treatise on air conditioning for hotels and apartments, including description of this company's equipment and service, typical installations, value of air conditioning to owners, managers, tenants and guests, and data on factors determining owning and operating costs, typical layouts and results achieved by various installations.

No. 954. AIR CONDITIONING: Frick Co., Waynesboro, Pa. 16 p. booklet illustrating and reporting results of various commercial and industrial air conditioning systems installed by Paul J. Vincent Co. in Baltimore and the South. Also, folder illustrating four types of compressors for air conditioning.

No. 955. AIR CONDITIONING: Servel, Inc., Evansville, Ind. Folder illustrating and briefly describing this company's

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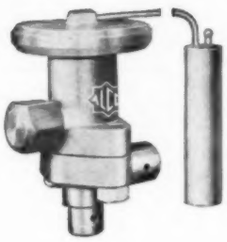

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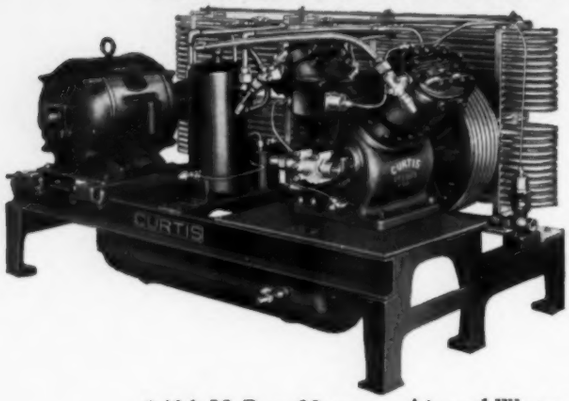

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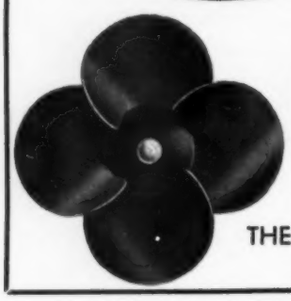

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No. 956. AIR CONDITIONING UNITS: Willard Metallic Crypt Co., Willard, O. 6 p. folder describing units using ice as cooling medium, one continuously pumping spray water at rate of 8¼ gpm with blower having an approximate capacity of 1100 cfm, and the other with 3280 cfm blower and circulating 30 gpm of water, rated at from 5 to 10 tons. The larger unit is designed for duct distribution and the other for location in the room cooled.

No. 957. AIR LIFTS: Ingersoll-Rand Co., 11 Broadway, New York, N. Y. 20 p. bulletin on pumping by compressed air by means of the air lift, explaining advantages, applications, design and volume control and giving technical data, formulas, dimensions, etc.

No. 958. AIR WASHERS: National Fan & Blower Corp., 543 W. Washington St., Chicago, Ill. 6 p. bulletin on double stage air washers, describing construction in detail, giving suggestions for selection and dimensions and general data, with pump specifications and pipe and valve sizes.

No. 959. ALLOYS: Climax Molybdenum Co., 500 Fifth Ave., New York, N. Y. 4 p. issue of the "Moly Matrix," including an article on chrome-moly steel rotors in fuel oil pumps.

No. 960. ALLOY STEELS: International Nickel Co., Inc., 67 Wall St., New York, N. Y. 12 p. bulletin giving data on low temperature properties of nickel alloy steels, including information on pressure vessels.

No. 961. BEARING UNITS: Link-Belt Co., 307 N. Michigan Ave., Chicago, Ill. 40 p. booklet on anti-friction bearing units, describing details of construction, selection, capacities and ratings, and giving tables of list prices, average weights, dimensions. Data on take-up units, pillow blocks and hangers are also presented.

No. 962. BLOWERS: Janette Mfg. Co., 556 W. Monroe St., Chicago, Ill. 4 p. price bulletin on motorized blowers of various types.

No. 963. BOILERS: Union Iron Works, Erie, Pa. 4 p. bulletin on water tube heating boilers for stoker firing, oil firing or hand firing, describing and illustrating design, construction and installation, and giving dimensions and ratings.

No. 964. BOILER TUBES: Babcock & Wilcox Tube Co., Beaver Falls, Pa. 16 p. booklet explaining effect of manufacturing process upon boiler tubes, and answering other questions of interest to buyers or users.

No. 965. BOOSTERS: Bell & Gossett Co., 3000 Wallace St., Chicago, Ill. Circular describing the economy and dependability of "B & G" boosters for meeting pumping requirements of hot water heating systems, and giving complete data on performance and construction features.

No. 966. COMBUSTION METERS: The Hays Corp., E. 8th St., Michigan City, Ind. 16 p. catalog of combustion recorders with information on how fuel losses vary with CO_2, describing advantages and construction of water operated CO_2 recorder, and giving detailed information on a complete line of this equipment.

No. 967. CONVECTORS: Young Radiator Co., Racine, Wis. Leaflet on advantages of a convection heater, briefly describing features of construction of "Streamaire" copper convectors.

No. 968. FANS: Propellair, Inc., 1345 Lagonda Ave., Springfield, O. 4 p. bulletin on new line of circulator fans, showing installations and size and capacity table.

No. 969. FILTERS: Staynew Filter Corp., 25 Leighton Ave., Rochester, N. Y. 4 p. leaflet on "Protectomotor" air line filters for delivering clean, dry, compressed air or other gases, and explaining in detail construction of standard and special models, and giving specifications and net prices.

No. 970. FIREBRICK: Babcock & Wilcox Co., 85 Liberty St., New York, N. Y. 8 p. booklet giving complete information on five types of insulating firebrick, including physical characteristics, thermal conductivity, applications, savings in time and

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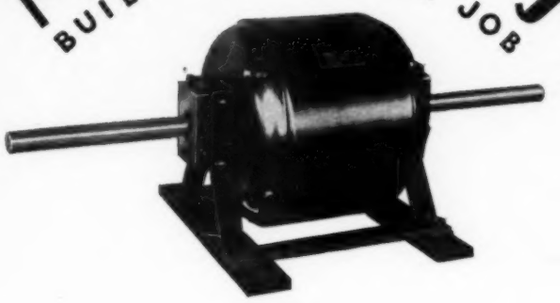

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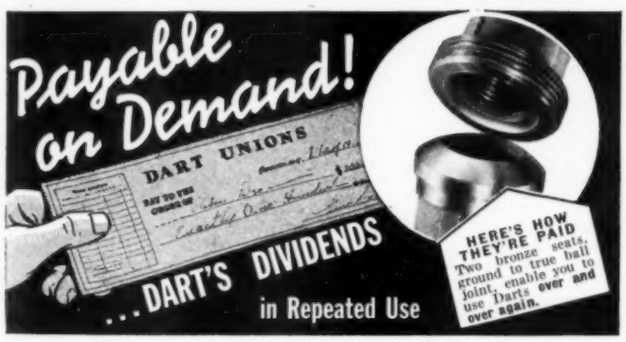
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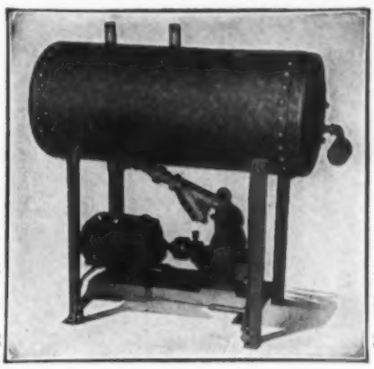

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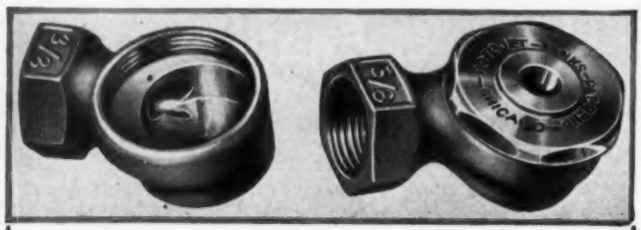

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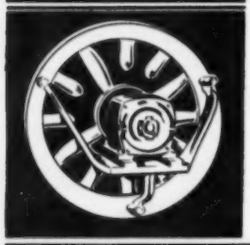

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No. 971. GRILLES AND REGISTERS: Independent Register Co., 3747 E. 93rd St., Cleveland, O. 36 p. catalog of air conditioning grilles and registers, with complete information and illustrations on an extensive line including many types, and presenting list prices, pressure-velocity curves, and tables and capacities.

No. 972. HEAT EXCHANGERS: The Sims Co., 18th & Whitley Sts., Erie, Pa. 8 p. bulletin on diesel exhaust gas and jacket water heat exchangers, describing construction, showing diagrams of various types of installations, and presenting size and dimension tables.

No. 973. INSTRUMENTS: Brown Instrument Co., Wayne & Roberts Aves., Philadelphia, Pa. Folder on the importance of instruments in industrial modernization, and booklet addressed to executives on the importance of instruments, their applications and the savings they make possible.

No. 974. INSULATION: Acme Asbestos Covering & Flooring Co., 236 N. Elizabeth St., Chicago, Ill. 20 p. catalog of asbestos "Blue Label" insulations, including 85 per cent magnesia pipe covering and blocks, pipe covering and blocks for 500 to 1200 F, air cell pipe covering, wool felt pipe covering, anti-sweat pipe covering, molded cork insulation, hair felt, insulating cements, gaskets and packings, as well as other types, including information on applications and prices.

No. 975. MOTORS: Ohio Electric Mfg. Co., 5910 Maurice Ave., Cleveland, O. 16 p. pictorial booklet on why this company's fractional horsepower motors are reliable, illustrating some of the manufacturing operations and describing their importance. A summary of the types of motors available is included.

No. 976. NICKEL CAST IRON: International Nickel Co., Inc., 67 Wall St., New York, N. Y. Pocket size booklet presenting notes on the uses of nickel cast iron in various industries, designed to be a handy reference on the subject. Also, 8 p. mimeographed booklet on the resistance of "Ni-Resist" to corrosion by sewage.

No. 977. PUMPS: Ingersoll-Rand Co., 11 Broadway, New York, N. Y. 6 p. bulletin on "Cameron Motorpumps" for air conditioning service, describing features of the design and applications in air conditioning, as well as illustrating installations.

No. 978. PUMPS: Ingersoll-Rand Co., 11 Broadway, New York, N. Y. 8 p. bulletin on "Cameron Motorpumps" for condensate return in plants, office buildings, apartment houses, department stores, school buildings, estates and clubs, illustrating and describing standard and special types, and giving information on installations, specifications, dimensions and capacities.

No. 979. PUMPS: Ingersoll-Rand Co., 11 Broadway, New York, N. Y. 4 p. bulletin on pumps in bulk fuel oil and gasoline stations, explaining advantages, and illustrating installations.

No. 980. REFRACTORIES: Babcock & Wilcox Co., 85 Liberty St., New York, N. Y. 8 p. booklet giving general characteristics and specific properties of each of five mortars and plastics, including information on selection for various types of work, and other data.

No. 981. REFRIGERATING EQUIPMENT: Trenton Auto Radiator Works, 626 Brunswick Ave., Trenton, N. J. 48 p. catalog of "Kramer" refrigerating equipment, including walk-in cooler equipment and hotel, restaurant and grocery equipment, describing and giving complete information on various types of coils, unit coolers, condensers and fittings, as well as controls and valves.

No. 982. REGISTERS: Hart & Cooley Mfg. Co., 61 W. Kinzie St., Chicago, Ill. 65 p. pocket guide to registers and accessory equipment, giving complete information on an extensive line. Also, a sizing chart giving recommended sizes of "H & C" forced air registers.

No. 983. STEAM ENGINES: Troy Engine & Machine Co., Troy, Pa. 48 p. catalog on steam engines, including information on uses and advantages, byproduct power, features of design of vertical and horizontal engines, with rated horsepower tables, water rate tables, specifications, erection drawings and construction details.

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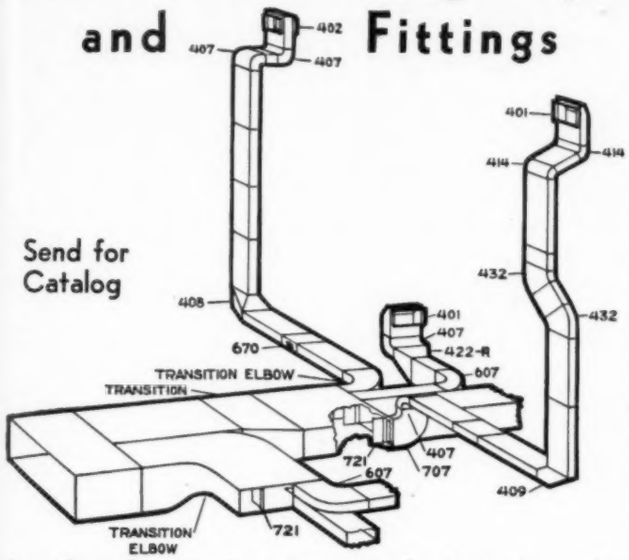

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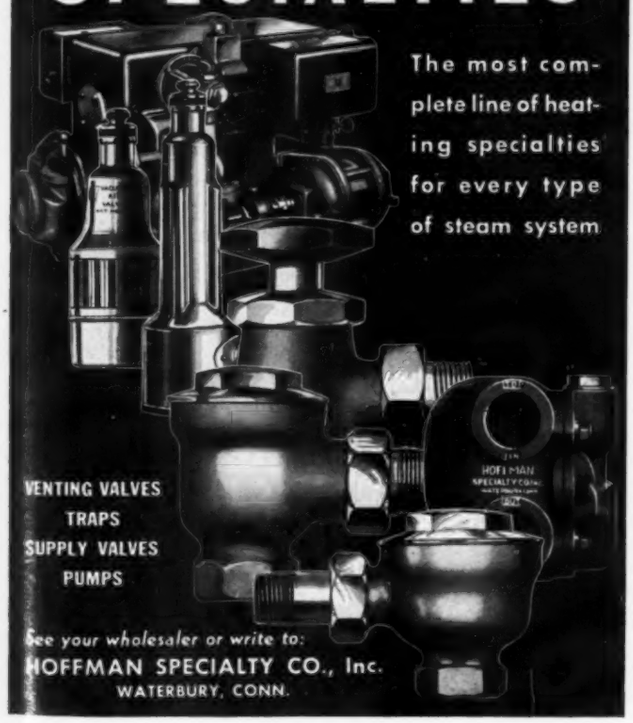

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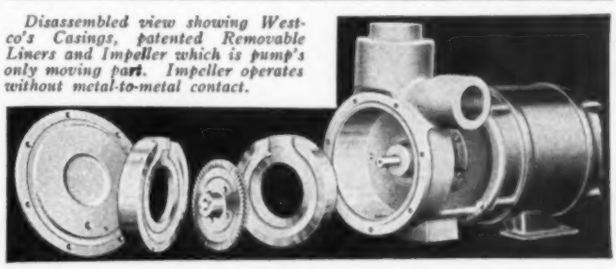

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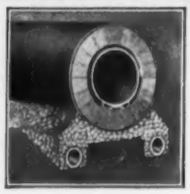

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No. 984. TAPS: Landis Machine Co., Inc., Waynesboro, Pa. Folder on collapsible taps for cutting straight and tapered threads, describing features and uses.

No. 985. THERMOMETERS: The Bristol Co., Waterbury, Conn. 88 p. catalog of thermometers, including liquid filled, vapor tension and gas filled recording, indicating and controlling thermometers, with information on automatic temperature controllers of the electric and pneumatic types, and sketches of applications. Application data are given on industrial stem thermometers, resistance thermometers, humidity measuring instruments, control valves, time-temperature controllers and accessories. Over 500 temperature recording charts are illustrated in full size.

No. 986. THERMOMETERS: Consolidated Ashcroft Hancock Co., Inc., American Schaeffer & Budenberg Div., 11 Elias St., Bridgeport, Conn. 4 p. bulletin on tin and copper case thermometers, dip thermometers, insulated and uninsulated hygrometers and pocket test thermometers.

No. 987. VALVES AND FITTINGS: Central Brass Mfg. Co., 2950 E. 55th St., Cleveland, O. 8 p. catalog of industrial faucets, valves and fittings.

No. 988. VALVES: Edward Valve & Mfg. Co., Inc., 1200 W. 145th St., East Chicago, Ind. 28 p. catalog on non-return valves, discussing selection of correct size, details of design, choice of materials and functions of the "Impactor" hand wheel. Data are included on valves for standard pressures from 250 lb to 1500 lb, illustrated by sectional views, tables of dimensions and tables of list prices and weights. A series of forged steel stop check valves, sizes ¼ to 2 in., is included.

No. 989. VENETIAN BLINDS: Bostwick-Goodell Co., Norwalk, O. Leaflets on venetian blinds and metal awnings for reducing solar heat gain of buildings.

No. 990. VIBRATION ELIMINATORS: Vibration Eliminator Co., 41-26 Thirty-seventh St., Long Island City, New York, N. Y. 12 p. booklet on vibration isolation of machinery, announcing improved vibration eliminators for loads between 50 and 400 lb, heavy duty vibration eliminators for loads from 500 to 2000 lb, giving recommendations for isolation with natural cork plates, and describing ceiling suspension vibration eliminators.

No. 991. WATER HEATERS: American District Steam Co., North Tonawanda, N. Y. Technical data sheets on copper U-tube water heaters of instantaneous or gravity recirculating type, describing applications, construction and typical installations, and giving dimensions, capacities and list price tables.

No. 992. ZONE CONTROL: Johnson Service Co., 507 E. Michigan St., Milwaukee, Wis. 24 p. catalog of zone control systems utilizing the "Duo-Stat," pointing out the need for automatic heat control and the advantages of zone heating, possible savings, features of the system, illustrating typical buildings equipped, showing a diagram of the complete system, and illustrating and describing the apparatus for zone control in detail. A number of diagrams illustrating application are presented.

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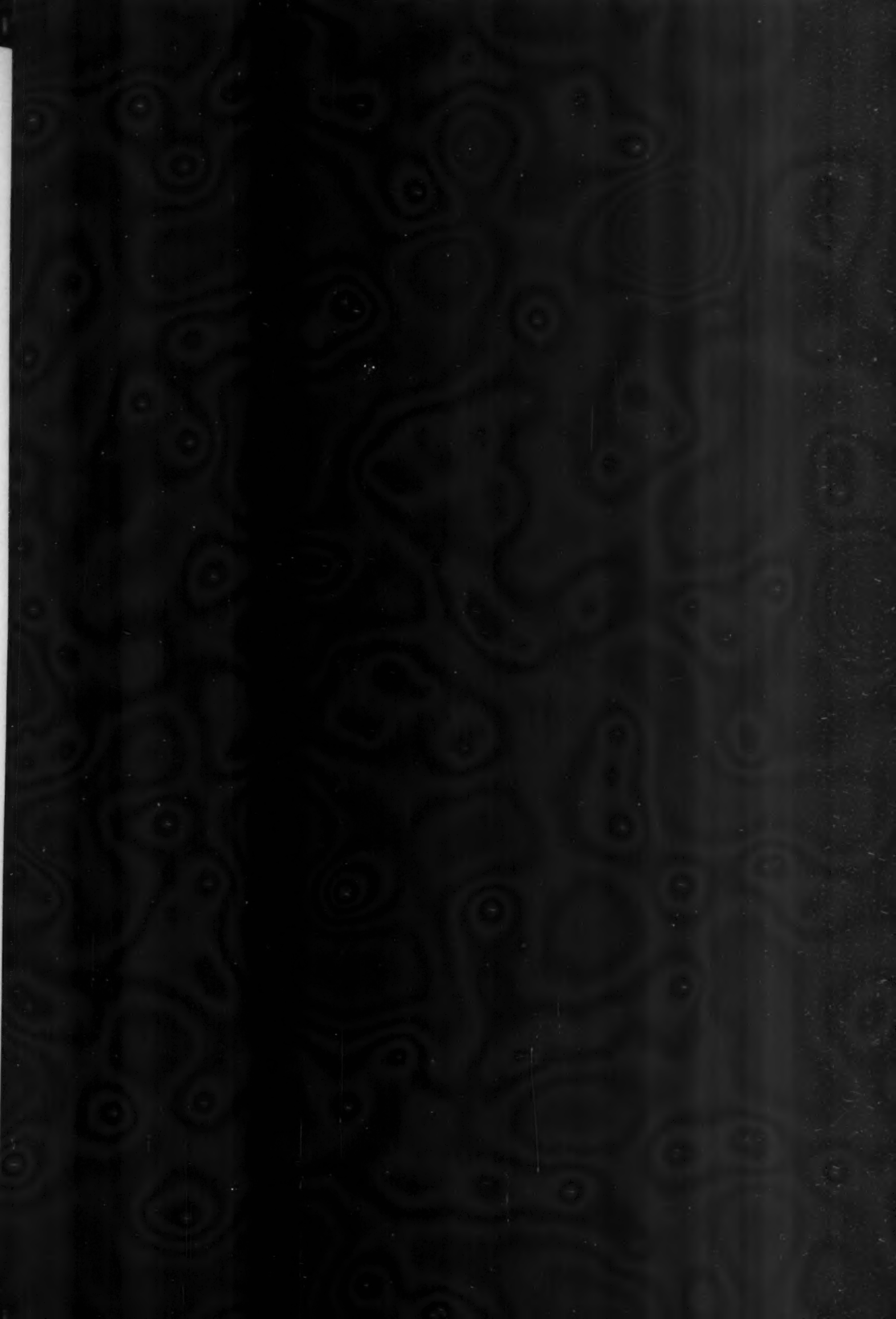
201	202	203	204	205	206	207	208	209
210	211	212	213	214	215	216	217	218
952	953	954	955	956	957	958	959	960
961	962	963	964	965	966	967	968	969
970	971	972	973	974	975	976	977	978
979	980	981	982	983	984	985	986	987
988	989	990	991	992				

Name ..... Title.....

Address .....

Company .....